

CLONING HUMAN BEINGS

Report and Recommendations of the
National Bioethics Advisory Commission

Rockville, Maryland
June 1997

CONTENTS

Letter of Transmittal to the President
Letter from the President
NBAC Roster
Staff Roster
Acknowledgments

Executive Summary -i-

1. Introduction	1
2. The Science and Application of Cloning	13
3. Religious Perspectives	39
4. Ethical Considerations	63
5. Legal and Policy Considerations	87
6. Recommendations of the Commission	107

Appendices

A. Glossary	1
B. List of Speakers	4
C. List of Commissioned Papers	5

June 9, 1997

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

On February 24, 1997, in the wake of the announcement that scientists in Scotland apparently had succeeded in cloning an adult sheep, you asked the National Bioethics Advisory Commission to review the legal and ethical issues associated with the use of this technology and to report back within ninety days with recommendations. A week later you instructed the heads of executive departments and agencies that "no federal funds shall be allocated for cloning of human beings" thereby ensuring that precipitous steps would not be taken while the Commission was studying the subject.

In this short interval, we have made every effort to consult with ethicists, theologians, scientists, physicians, and other citizens with interests and concerns in this area. Moreover, we have invited inputs for the Commission's consideration from as broad a cross-section of the community as time allowed. Further, recognizing that science and medicine are international activities with outstanding investigators and facilities in many nations, we have attempted to review relevant policies and proposals with respect to human cloning in other countries. However, we do not view it as essential to follow others in this area unless we find their proposals compelling, since we have different political and cultural traditions.

In this report, we address a very specific aspect of cloning namely where genetic material would be transferred from the nucleus of a somatic cell of an existing human being to an enucleated human egg with the intention of creating a child. We do not revisit either the question of the cloning of humans by embryo-splitting or the issues surrounding embryo research. The latter issue has, of course, recently received careful attention by a National Institutes of Health panel, the Administration, and Congress.

Not surprisingly, we have discovered that the potential ability to clone human beings through the somatic cell nuclear transfer techniques raises a whole host of complex and difficult scientific, religious, legal and ethical issues--both new and old. Indeed, the Commission itself is unable to agree at this time on all the ethical issues that surround the issue of cloning human beings in this manner. It seems clear to all of us, however, given the current stage of science in this area, that any attempt to clone human beings via somatic cell nuclear transfer techniques is uncertain in its prospects, is unacceptably dangerous to the fetus and, therefore, morally unacceptable. At present, moral consensus on this issue should be easily achieved. Furthermore, the continuing

controversy over the social and ethical issues raised by this new development require more time for deliberation and the accumulation of new scientific data. We therefore recommend that the current moratorium on attempts to create children in this manner be continued and that you immediately ask for voluntary compliance in the private sector while federal legislation banning the use of these techniques for creating children is formulated and considered.

While we have been able to agree on this and certain other recommended actions, we feel quite strongly that most of the legal and moral issues raised can only be resolved, even temporarily, by a great deal more widespread deliberation and education. This type of national discussion is especially necessary in our democratic and pluralistic society for the following reasons: there is no universally accepted ethical theory; Americans hold various religious and moral perspectives on these issues; conflicting values are at stake; Americans differ on the importance and meaning of particular traditions; tolerance (agreeing to disagree) governs wide areas of our national life; and given our historical traditions, we are strongly inclined to leave to the individual conscience those acts that do not harm others and on which there is no moral consensus.

As a result, we must continue to build our understanding of the widespread public concern that has been generated by these recent developments. Some of this concern can be explained by an inadequate understanding of the issues--sometimes even confusing science and science fiction. This matter, however, can be addressed over time through further public education. Other concerns, however, run much deeper and range from the implications for particular faith commitments, to views regarding the appropriate sphere for human action, to concerns regarding the future of the family, to cumulative apprehensions about the real net benefit of a rapidly advancing technology that some believe is too aggressively pushing aside important social and moral values. As we move ahead to the next stage of our national discussion, these are among the many issues that need to be thoughtfully addressed.

Finally, while our specific recommendations include continuing the moratorium you announced in February of this year, and a call for a specific federal legislation, the report also includes important sections outlining the scientific, religious, ethical and legal issues that are raised by these new scientific developments. It is our hope that these materials, by clarifying certain issues and highlighting others, will form a useful initial basis for the ongoing deliberations and educational dialogues that we believe are so essential. We have been impressed by the difficulties caused by the lack of knowledge about genetics and the science involved in cloning revealed in the public and media responses to the cloning of Dolly the sheep. We believe, therefore, that the federal government should continue to actively encourage public education in this area of science so that as public deliberation takes place it is as informed as possible.

I would like to take this opportunity to thank all the Commissioners and our very dedicated staff for the intensity and depth of their commitment to the task that you assigned to us.

Sincerely,

Harold T. Shapiro
THE WHITE HOUSE

WASHINGTON

February 24, 1997

Dr. Harold Shapiro
Chair
National Bioethics
Advisory Commission
Suite 3C01
6100 Executive Boulevard
Bethesda, Maryland 20892-7508

Dear Dr. Shapiro:

As you know, it was reported today that researchers have developed techniques to clone sheep. This represents a remarkable scientific discovery, but one that raises important questions. While this technological advance could offer potential benefits in such areas as medical research and agriculture, it also raises serious ethical questions, particularly with respect to the possible use of this technology to clone human embryos.

Therefore, I request that the National Bioethics Advisory Commission undertake a thorough review of the legal and ethical issues associated with the use of this technology, and report back to me within ninety days with recommendations on possible federal actions to prevent its abuse.

Sincerely,

Bill Clinton

National Bioethics Advisory Commission

Harold T. Shapiro, Ph.D. - Chair

President
Princeton University
Princeton, New Jersey

Patricia Backlar

Senior Scholar
Center for Ethics in Health Care
Oregon Health Sciences University
Portland, Oregon
Senior Research Associate
Department of Philosophy
Portland State University
Portland, Oregon

Arturo Brito, M.D.

Assistant Professor of Clinical Pediatrics
University of Miami School of Medicine
Miami, Florida

Alexander Morgan Capron, LL.B.

Henry W. Bruce Professor of Law
University Professor of Law and Medicine
Co-Director, Pacific Center for Health Policy and Ethics
University of Southern California
Los Angeles, California

Eric J. Cassell, M.D.

Clinical Professor of Public Health
Cornell University Medical College
New York, New York

R. Alta Charo, J.D.

Associate Professor of Law and
Medical Ethics
Schools of Law and Medicine
University of Wisconsin
Madison, Wisconsin

James F. Childress, Ph.D.

Kyle Professor of Religious Studies
Professor of Medical Education
Department of Religious Studies
University of Virginia
Charlottesville, Virginia

David R. Cox, M.D., Ph.D.

Professor of Genetics and Pediatrics
Department of Genetics
Stanford University School of Medicine
Stanford, California

Rhetaugh Graves Dumas, Ph.D., R.N.

Vice Provost for Health Affairs
Lucille Cole Professor of Nursing
The University of Michigan
Ann Arbor, Michigan

Ezekiel J. Emanuel, M.D., Ph.D.

Associate Professor of Medical Ethics
Department of Social Medicine
Harvard Medical School
Boston, Massachusetts

Laurie M. Flynn

Executive Director
National Alliance for the
Mentally Ill
Arlington, Virginia

Carol W. Greider, Ph.D.

Senior Staff Scientist
Cold Spring Harbor Laboratory
Cold Spring Harbor, New York

Steven H. Holtzman

Chief Business Officer
Millennium Pharmaceuticals Inc.
Cambridge, Massachusetts

Bette O. Kramer

Founding President
Richmond Bioethics Consortium
Richmond, Virginia

Bernard Lo, M.D.

Director
Program in Medical Ethics
University of California at San Francisco
San Francisco, California

Lawrence H. Mäike, M.D., J.D.

Director
State Department of Health
Honolulu, Hawaii

Thomas H. Murray, Ph.D.

Professor and Director
Center for Biomedical Ethics
School of Medicine
Case Western Reserve University
Cleveland, Ohio

Diane Scott-Jones, Ph.D.

Professor
Department of Psychology
Temple University
Philadelphia, Pennsylvania

National Bioethics Advisory Commission

Staff

Executive Director, Acting
William F. Raub, Ph.D

Deputy Executive Director, Acting
Ms. Henrietta D. Hyatt-Knorr, M.A.

Executive Assistant
Ms. Patricia Norris

Program Director
Ms. Margaret C. Quinlan

Director, Human Subjects Protections Project
William Freeman, M.D., M.P.H.

Senior Analyst (Volunteer)
Joel Mangel, J.D.

Analysts
Ms. Emily Feinstein
Mr. E. Randolph Hull, Jr.
Mr. Sean Simon
Mr. Robert Tanner

Senior Secretary
Ms. Robin Dorsey

Secretary
Ms. LaShell Gaskins

Senior Consultant
Kathi E. Hanna, Ph.D.

Acknowledgments

The Commission wishes to express its special gratitude to those scholars who on very short notice and under very tight time constraints prepared at the Commission's request very thoughtful presentations and papers on the issues before the Commission. These scholars include: Lori B. Andrews, Dan W. Brock, Lisa Cahill, Courtney S. Campbell, Robert Mullan Cook-Deegan, Elisa Eiseman, Rabbi Elliot Dorff, Nancy Duff, Leon R. Kass, Bartha Maria Knoppers, Ruth Macklin, Gilbert C. Meilaender, Father Albert S. Moraczewski, James L. Nelson, Stuart H. Orkin, John Robertson, Janet Rossant, Abdul Aziz Sachedina, Rabbi Moshe Tendler, and Shirley Tilghman.

The Commission also wishes to thank Kathi E. Hanna, Henrietta Hyatt-Knorr, and the NBAC staff for their unfailing commitment through the ninety days in which this report was formulated and produced. Others who provided superior support include William Raub in his role as Acting Executive Director, Lily Engstrom, Hal Thompson, Damon Thompson, Donna Young, Timothy Morris, Vito Oporto, Janet Miller, Marcia Snowden, and Rosemarie Menz.

EXECUTIVE SUMMARY

The idea that humans might someday be cloned—created from a single somatic cell without sexual reproduction—moved further away from science fiction and closer to a genuine scientific possibility on February 23, 1997. On that date, *The Observer* broke the news that Ian Wilmut, a Scottish scientist, and his colleagues at the Roslin Institute were about to announce the successful cloning of a sheep by a new technique which had never before been fully successful in mammals. The technique involved transplanting the genetic material of an adult sheep, apparently obtained from a differentiated somatic cell, into an egg from which the nucleus had been removed. The resulting birth of the sheep, named Dolly, on July 5, 1996, was different from prior attempts to create identical offspring since Dolly contained the genetic material of only one parent, and was, therefore, a "delayed" genetic twin of a single adult sheep.

This cloning technique is an extension of research that had been ongoing for over 40 years using nuclei derived from non-human embryonic and fetal cells. The demonstration that nuclei from cells derived from an adult animal could be "reprogrammed," or that the full genetic complement of such a cell could be reactivated well into the chronological life of the cell, is what sets the results of this experiment apart from prior work. In this report the technique, first described by Wilmut, of nuclear transplantation using nuclei derived from somatic cells other than those of an embryo or fetus is referred to as "somatic cell nuclear transfer."

Within days of the published report of Dolly, President Clinton instituted a ban on federal funding related to attempts to clone human beings in this manner. In addition, the President asked the recently appointed National Bioethics Advisory Commission (NBAC) to address within ninety days the ethical and legal issues that surround the subject of cloning human beings. This provided a welcome opportunity for initiating a thoughtful analysis of the many dimensions of the issue, including a careful consideration of the potential risks and benefits. It also presented an occasion to review the current legal status of cloning and the potential constitutional challenges that might be raised if new legislation were enacted to restrict the creation of a child through somatic cell nuclear transfer cloning.

The Commission began its discussions fully recognizing that any effort in humans to transfer a somatic cell nucleus into an enucleated egg involves the creation of an embryo, with the apparent potential to be implanted in utero and developed to term. Ethical concerns surrounding issues of embryo research have recently received extensive analysis and deliberation in the United States. Indeed, federal funding for human embryo research is severely restricted, although there are few restrictions on human embryo research carried out in the private sector. Thus, under current law, the use of somatic cell nuclear transfer to create an embryo solely for research purposes is already restricted in cases involving federal funds. There are, however, no current federal regulations on the use of private funds for this purpose.

The unique prospect, vividly raised by Dolly, is the creation of a new individual genetically identical to an existing (or previously existing) person—a "delayed" genetic twin. This prospect

has been the source of the overwhelming public concern about such cloning. While the creation of embryos for research purposes alone always raises serious ethical questions, the use of somatic cell nuclear transfer to create embryos raises no new issues in this respect. The unique and distinctive ethical issues raised by the use of somatic cell nuclear transfer to create children relate to, for example, serious safety concerns, individuality, family integrity, and treating children as objects. Consequently, the Commission focused its attention on the use of such techniques for the purpose of creating an embryo which would then be implanted in a woman's uterus and brought to term. It also expanded its analysis of this particular issue to encompass activities in both the public and private sector.

In its deliberations, NBAC reviewed the scientific developments which preceded the Roslin announcement, as well as those likely to follow in its path. It also considered the many moral concerns raised by the possibility that this technique could be used to clone human beings. Much of the initial reaction to this possibility was negative. Careful assessment of that response revealed fears about harms to the children who may be created in this manner, particularly psychological harms associated with a possibly diminished sense of individuality and personal autonomy. Others expressed concern about a degradation in the quality of parenting and family life.

In addition to concerns about specific harms to children, people have frequently expressed fears that the widespread practice of somatic cell nuclear transfer cloning would undermine important social values by opening the door to a form of eugenics or by tempting some to manipulate others as if they were objects instead of persons. Arrayed against these concerns are other important social values, such as protecting the widest possible sphere of personal choice, particularly in matters pertaining to procreation and child rearing, maintaining privacy and the freedom of scientific inquiry, and encouraging the possible development of new biomedical breakthroughs.

To arrive at its recommendations concerning the use of somatic cell nuclear transfer techniques to create children, NBAC also examined long-standing religious traditions that guide many citizens' responses to new technologies and found that religious positions on human cloning are pluralistic in their premises, modes of argument, and conclusions. Some religious thinkers argue that the use of somatic cell nuclear transfer cloning to create a child would be intrinsically immoral and thus could never be morally justified. Other religious thinkers contend that human cloning to create a child could be morally justified under some circumstances, but hold that it should be strictly regulated in order to prevent abuses.

The public policies recommended with respect to the creation of a child using somatic cell nuclear transfer reflect the Commission's best judgments about both the ethics of attempting such an experiment and its view of traditions regarding limitations on individual actions in the name of the common good. At present, the use of this technique to create a child would be a premature experiment that would expose the fetus and the developing child to unacceptable risks. This in itself might be sufficient to justify a prohibition on cloning human beings at this time, even if such efforts were to be characterized as the exercise of a fundamental right to attempt to

procreate.

Beyond the issue of the safety of the procedure, however, NBAC found that concerns relating to the potential psychological harms to children and effects on the moral, religious, and cultural values of society merited further reflection and deliberation. Whether upon such further deliberation our nation will conclude that the use of cloning techniques to create children should be allowed or permanently banned is, for the moment, an open question. Time is an ally in this regard, allowing for the accrual of further data from animal experimentation, enabling an assessment of the prospective safety and efficacy of the procedure in humans, as well as granting a period of fuller national debate on ethical and social concerns. The Commission therefore concluded that there should be imposed a period of time in which no attempt is made to create a child using somatic cell nuclear transfer.¹

Within this overall framework the Commission came to the following conclusions and recommendations:

I. The Commission concludes that at this time it is morally unacceptable for anyone in the public or private sector, whether in a research or clinical setting, to attempt to create a child using somatic cell nuclear transfer cloning. The Commission reached a consensus on this point because current scientific information indicates that this technique is not safe to use in humans at this point. Indeed, the Commission believes it would violate important ethical obligations were clinicians or researchers to attempt to create a child using these particular technologies, which are likely to involve unacceptable risks to the fetus and/or potential child. Moreover, in addition to safety concerns, many other serious ethical concerns have been identified, which require much more widespread and careful public deliberation before this technology may be used.

The Commission, therefore, recommends the following for immediate action:

- A continuation of the current moratorium on the use of federal funding in support of any attempt to create a child by somatic cell nuclear transfer.
- An immediate request to all firms, clinicians, investigators, and professional societies in the private and non-federally funded sectors to comply voluntarily with the intent of the federal moratorium. Professional and scientific societies should make clear that any attempt to create a child by somatic cell nuclear transfer and implantation into a woman's body would at this time be an irresponsible, unethical, and unprofessional act.

II. The Commission further recommends that:

¹ The Commission also observes that the use of any other technique to create a child genetically identical to an existing (or previously existing) individual would raise many, if not all, of the same non-safety-related ethical concerns raised by the creation of a child by somatic cell nuclear transfer.

- Federal legislation should be enacted to prohibit anyone from attempting, whether in a research or clinical setting, to create a child through somatic cell nuclear transfer cloning. It is critical, however, that such legislation include a sunset clause to ensure that Congress will review the issue after a specified time period (three to five years) in order to decide whether the prohibition continues to be needed. If state legislation is enacted, it should also contain such a sunset provision. Any such legislation or associated regulation also ought to require that at some point prior to the expiration of the sunset period, an appropriate oversight body will evaluate and report on the current status of somatic cell nuclear transfer technology and on the ethical and social issues that its potential use to create human beings would raise in light of public understandings at that time.

III. The Commission also concludes that:

- Any regulatory or legislative actions undertaken to effect the foregoing prohibition on creating a child by somatic cell nuclear transfer should be carefully written so as not to interfere with other important areas of scientific research. In particular, no new regulations are required regarding the cloning of human DNA sequences and cell lines, since neither activity raises the scientific and ethical issues that arise from the attempt to create children through somatic cell nuclear transfer, and these fields of research have already provided important scientific and biomedical advances. Likewise, research on cloning animals by somatic cell nuclear transfer does not raise the issues implicated in attempting to use this technique for human cloning, and its continuation should only be subject to existing regulations regarding the humane use of animals and review by institution-based animal protection committees.
- If a legislative ban is not enacted, or if a legislative ban is ever lifted, clinical use of somatic cell nuclear transfer techniques to create a child should be preceded by research trials that are governed by the twin protections of independent review and informed consent, consistent with existing norms of human subjects protection.
- The United States Government should cooperate with other nations and international organizations to enforce any common aspects of their respective policies on the cloning of human beings.

IV. The Commission also concludes that different ethical and religious perspectives and traditions are divided on many of the important moral issues that surround any attempt to create a child using somatic cell nuclear transfer techniques. Therefore, the Commission recommends that:

- The federal government, and all interested and concerned parties, encourage widespread and continuing deliberation on these issues in order to further our understanding of the ethical and social implications of this technology and to enable society to produce appropriate long-term policies regarding this technology should the time come when present concerns about safety have been addressed.

V. Finally, because scientific knowledge is essential for all citizens to participate in a full and informed fashion in the governance of our complex society, the Commission recommends that:

- Federal departments and agencies concerned with science should cooperate in seeking out and supporting opportunities to provide information and education to the public in the area of genetics, and on other developments in the biomedical sciences, especially where these affect important cultural practices, values, and beliefs.

Chapter One

INTRODUCTION

The idea that humans might someday be cloned—created from a single somatic cell without sexual reproduction—moved further away from science fiction and closer to a genuine scientific possibility on February 23, 1997. On that date, *The Observer* broke the news that Ian Wilmut, a Scottish scientist, and his colleagues at the Roslin Institute were about to announce the successful cloning of a sheep by a new technique. The technique involved transplanting the genetic material of an adult sheep, apparently obtained from a differentiated somatic² cell, into an egg from which the nucleus had been removed. The resulting birth of the sheep, named Dolly, on July 5, 1996 appears to mark yet another milestone in our ability to control, refine, and amplify the forces of nature.

The Scottish sheep experiment was different from prior attempts to create identical offspring from a pair of adult animals. It used a cloning technique to produce an animal that was a genetic twin of an adult sheep. Put another way, Dolly contained the genetic material of only one parent. This technique of transferring a nucleus from a somatic cell into an egg is an extension of research that had been ongoing for over 40 years using nuclei derived from non-human embryonic and fetal cells. The demonstration that nuclei from cells derived from an adult animal could be "reprogrammed," or that the full genetic complement of such a cell could be reactivated well into the chronological life of the cell, is what sets the results of this experiment apart from prior work. In this report the technique, first reported by Wilmut, of nuclear transplantation using nuclei derived from somatic cells other than those of an embryo or fetus is referred to as "somatic cell nuclear transfer."

For some time, scientific evidence has suggested that the genetic material contained in differentiated somatic cells may retain the potential to direct the development of healthy fertile adult animals, but its capacity to do so remained unproved (Di Bernadino, 1997). The Roslin experiment, therefore, was a significant scientific event with potentially profound implications since it brings us closer to the possibility of developing a capacity to create clone human beings in an asexual manner. Although for the past ten years scientists have routinely cloned sheep and cows from embryo cells, this was the first successful experiment using the nucleus of a somatic cell from an adult animal to clone an animal that matured to a fully developed state.

The issues surrounding the cloning of human beings have long been the subject of periodic concern and debate among philosophers, scientists, ethicists, and others, particularly following the

² A somatic cell is any cell of the embryo, fetus, child, or adult which contains a full complement of two sets of chromosomes; in contrast with a germ cell, i.e., an egg or a sperm, which contains only one set of chromosomes.

publication of Joshua Lederberg's 1966 article on cloning in the *American Naturalist* (Lederberg, 1966). Nevertheless, the impact of these most recent developments on our national psyche has been quite remarkable. Some commentators have suggested that the furor aroused by the new possibility for cloning is out of proportion to most of the ethical, legal, and moral issues it raises, since these same issues have been raised by previous developments and are simply emerging again in a novel and striking form. Nevertheless, it is important to acknowledge that the possibilities raised by this new technique certainly would be unprecedented and that some would consider its use to be a truly radical step. This type of cloning would involve three novel developments: the replacement of sexual procreation with asexual replication of an existing set of genes; the ability to predetermine the genes of a child; and the ability to create many genetically identical offspring.

Some scientists were surprised that the technical barriers of cell differentiation and development seemingly could be so easily overcome when using somatic cells as the source for nuclear transfer. The public—including many members of the scientific community—responded to Dolly with a combination of fascination, hope for useful new understandings of human biology, and profound concern—even alarm—about the prospect of being able to create whole humans from a single somatic cell via nuclear transfer cloning techniques. Although much of the initial public reaction was one of fear, concern, and serious moral reservations about the potential use or abuse of this new technological capacity, a few voices were heard cautiously suggesting that a better understanding of cell dynamics in humans and animals might enable us to develop new cures for various diseases. Thus, it is important to reflect not only on the dangers and ethical reservations but also on the potential human benefits from the use of this type of cloning that might arise in such areas as treating particular infertility problems, transplanting cells or tissues, or preventing certain genetically transmitted harms to offspring.

A few of the initial objections to this new type of cloning were either speculative or based on simple misunderstandings, such as, that cloning would allow for the instantaneous creation of a fully grown adult from the cells of an individual. Other fears stemmed from the incorrect idea that an exact copy, although much younger, of an existing person could be made. This fear reflects an erroneous belief that one's genes bear a simple relationship to the physical and psychological traits that make up a person. Although genes provide the building blocks for each individual, it is the interaction among a person's genetic inheritance, the physical and cultural environment, and the process of learning that result in the uniqueness of each individual human. Thus, the idea that nuclear transplantation cloning could be used to re-create exemplary or evil people has no scientific basis and is simply false.

Other objections to nuclear transplantation cloning, however, are based on carefully articulated philosophical ideals, deep cultural commitments, or religious beliefs, and these deserve continuing and careful consideration. These objections reflect deeply held beliefs about the value of human individuality and personal autonomy, the meaning of family and the value of a child, respect for human life and the natural world, and the preservation of the integrity of the human species.

Many public leaders in the United States responded to the announcement about Dolly with immediate and strong condemnation of any attempt to clone human beings in this new manner. The reasons ranged from frightening science fiction imagery to the judgment that cloning of human beings is a serious violation of basic human rights and human dignity. The reaction abroad was similar, with many nations seemingly ready—indirectly or directly—to prohibit cloning human beings in this fashion. Indeed, many international organizations such as UNESCO and the Council of Europe have a long-established and well-articulated concern that research and clinical applications in biology and genetics remain consistent with a fundamental commitment to human dignity and human rights. To date, at least Argentina, Australia, Great Britain, Denmark, Germany, and Spain have enacted laws banning cloning human beings. Unfortunately, some of the deep concerns supporting such views and associated legislation are stated in vague or overly broad terms. The widespread public discomfort, even revulsion, about cloning human beings deserves the best articulation possible, a task that takes time and requires the considered reflections of diverse groups within American society and abroad.

Within days of the published report of the apparently successful cloning of a sheep in this new manner, President Clinton instituted a ban on federal funding for research related to cloning of human beings. In addition, the President asked the recently appointed National Bioethics Advisory Commission (NBAC) to address within ninety days the ethical and legal issues that surround the subject of cloning human beings. This provided a welcome opportunity for initiating a thoughtful analysis of the many dimensions of the issue, including a careful consideration of the potential risks and benefits. It also presented an occasion to review the current legal status of cloning and the potential constitutional challenges that might be raised if new legislation were enacted to restrict the creation of a child through somatic cell nuclear transfer.

The Commission began its discussions fully recognizing that any effort in humans to transfer a somatic cell nucleus into an enucleated egg involves the creation of an embryo, with the apparent potential to be implanted *in utero* and developed to term. Ethical concerns surrounding issues of embryo research have recently received extensive analysis and deliberation in our country. Indeed, federal funding for human embryo research is severely restricted, although there are few restrictions on human embryo research carried out in the private sector. Thus, under current law, the use of somatic cell nuclear transfer to create an embryo solely for research purposes is already restricted in cases involving federal funds. There are, however, no current regulations on the use of private funds for this purpose.

The unique prospect, vividly raised by Dolly, is the creation of a new individual genetically identical to an existing (or previously existing) person—a “delayed” genetic twin. This prospect has been the source of the overwhelming public concern about such cloning. While the creation of embryos for research purposes alone always raises serious ethical questions, the use of somatic cell nuclear transfer to create embryos raises no new issues in this respect. The unique and distinctive ethical issues raised by the use of somatic cell nuclear

transfer to create children relate to, for example, serious safety concerns, individuality, family integrity, and treating children as objects. Consequently, the Commission focused its attention on the use of such techniques for the purpose of creating an embryo which would then be implanted in a woman's uterus and brought to term. It also expanded its analysis of this particular issue to encompass activities in both the public and private sector.

Controlling Nature

Humankind's efforts to control nature date back as far as recorded history. In particular, domesticated plants and animals have been the mainstay of our agricultural heritage. Over time human mastery over nature often has been met, quite understandably, with opposition and concern, and frequently has been considered by some to be an affront to the natural order of things or by others to be at odds with interpretations of God's revealed word. Indeed many myths and legends, ancient as well as modern, deal directly with humankind's on-going struggle to ensure that the benefits of our new technological capacities clearly outweigh the harms—both expected and unexpected. The idea that our growing technological mastery is filled with moral ambiguity and capable of both vast good and catastrophic evil is deeply embedded in many cultural traditions.

A prime example is the mythology of the Argo, the first ship, in classical Greek culture. The Greeks see the initial act of shipbuilding as both the origin of culture and the origin of decline. While sailing enables one to encounter other persons and other possibilities, it also brings marauders and war, and its very existence bespeaks the danger of unlimited human desire. Thus, the ability to build and sail boats is both a boon and a curse. Euripides' *Medea* starts with a lament about the trees that were cut down to build the Argo and the other troubles that followed:

Would that the Argo had never winged its way to the land of Colchis....
Would that pine trees had never been felled in the glens of Mount Pelion and
furnished oars for the hands of the heroes who at Pelias' command set forth in
quest of the Golden Fleece.

Concern about our tools and technology has been greatly accelerated with the coming of modern industrialized societies. Is it possible, some now wonder, that our confidence in human competence and technology may be just another myth? How, some are now asking, can we find some moral compass or moral limit to our desire to master everything and possess all? Only such limits, many would say, can save us from the moral ambiguity of our own cleverness.

In recent years, concern about humankind's control over nature has been particularly acute in relation to the new moral choices created by the stunning developments in the biomedical sciences, especially in the area of human reproduction. Although personal reproductive health is considered to be, in most cases, a private matter, ongoing controversies regarding the moral standing of human genetic material and particular human interventions in procreation have focused public attention on the ethical and legal implications of new reproductive techniques. In many

cases, initial fears give way to cautious acceptance, but a wariness lingers that is easily reawakened with each new advance.

Artificial insemination by donor, for example, was considered a form of adultery when first introduced in the 1940s. It is now a widely used and accepted practice in the treatment of infertility, although some continue to have serious reservations. When prenatal diagnosis was introduced in the late 1960s, the public simultaneously welcomed the opportunity to prevent lethal disease in newborns but worried about the use of such techniques to select "vanity" characteristics or nonmedical traits in offspring. The birth of Louise Brown, conceived via *in vitro* fertilization, in 1978 was another dramatic event, providing a new and controversial means to parenthood. With all of these technical advances, there has been a continuing debate about safety, legality, ethical acceptability, and the government's right to intervene in private matters.

Research itself, not just its clinical application, has often sparked debate. For example, research involving human fetuses has been a subject of intense national debate and disagreement for over two decades (Institute of Medicine, 1994). Federal research in this area continues to be restricted to that which has potential therapeutic benefit to the fetus, or involves no more than minimum risk to the fetus even if potential benefit to the mother can be demonstrated. Restrictions also remain regarding embryo research. Despite the recommendations of the National Institutes of Health Human Embryo Research Panel (1994), that certain targeted and carefully regulated research using early human embryos be eligible for federal funds, in December 1994 the President directed NIH not to allocate federal funds for research programs that involved the creation of human embryos solely for research purposes. This issue was also addressed by Congress, which inserted language in the FY96 and FY97 appropriations bills that widened the presidential ban to prohibit virtually all human embryo research conducted with federal funds. Work in this area continues in the United States, but it is largely limited to the private sector, and thus takes place without any federal regulation.

Recombinant DNA research represents another example of controversy and intense debate. In the 1970s, concerns about the safety of unintended release of recombinant organisms led to a voluntary research moratorium in the scientific community and the development of guidelines (Fredrickson, 1991). Similarly, all experiments involving gene therapy (treatment of specific diseases by inserting human genes into human patients) are subject to review and approval by a federal body.

As segments of human DNA or human cells became the focus of study and the objects of manipulation, their use as research materials raised increasingly important ethical issues about how these materials are obtained, transformed, and, in some cases, used to develop commercial products (Office of Technology Assessment, 1987). Such research with human genetic material generates questions about respect for persons and the human body, and the value and moral status to be placed on cells and tissues.

Genetic and reproductive technologies also cause concern because of the specter of eugenics and of real or imagined social control through manipulation of human genes. Genetic control suggests broken taboos, and, in the words of Henry David Thoreau, implies that “men have become the tools of their tools”(Blank, 1981). While these concerns are often set against and partly attributable to a backdrop of fiction, fantasy, and misunderstanding, they are, more importantly, related to profound concerns regarding the nature of humankind and its relationship to other aspects of the natural world.³ When the bizarre and fantastic scenarios are removed, we are left with a myriad of reactions: sincere expressions of opposition; serious moral concerns; new hope for a better understanding of human biology and the prospect of combating currently untreatable afflictions; calls for more study; and guarded statements about the need for some measure of control (Macklin, 1994; 1997).

Controlling Science

With some notable exceptions, the scientific community has enjoyed for centuries a great deal of autonomy in directing and regulating its research agenda. Since mid-century, however, demands for external regulation have increased, in part because much research, particularly in the biological sciences, is publicly funded and therefore requires some additional measure of accountability. More importantly, society has become more sensitive to concerns about the dangers—particularly to human participants—of the research itself and its future consequences. Thus, our evolving moral sensibilities together with the spectacular advances in biomedical science have generated new ethical concerns. As Bernard Davis of Harvard Medical School and others have noted, society sometimes seeks to regulate or restrict research when it poses the specters of dangerous or unfamiliar products, powers, or ideas (Davis, 1980).

The regulation of science has thus become part of the landscape, particularly for those who receive federal funds (Office of Technology Assessment, 1986). In addition to environmental, health, occupational, and safety regulations, scientists must also comply with animal welfare and human subjects protections and abide by restrictions and moratoria on specific types of research. Because science is both a public and social enterprise and its application can have profound impact, society recognizes that the freedom of scientific inquiry is not an absolute right and scientists are expected to conduct their research according to widely held ethical principles. There are times when limits on scientific freedom must be imposed, even if such limits are perceived as an impediment by an individual scientist. Moreover, appropriate ethical constraints are a matter for both scientists and the broader public to formulate and implement. At the same time, limits on freedom of inquiry must be justified, and impositions on such freedom should satisfy certain conditions—for example, that the limits are not arbitrary, that

³ With respect to interesting fiction consider Aldous Huxley's Brave New World (1932), David Rorvik's unsubstantiated claim of successful human cloning in In His Image (1978), and popular films such as The Boys from Brazil (1978) and Jurassic Park (1993) in which cloning leads to dire, doomsday consequences.

they emerge from the thoughtful balancing of costs and benefits, that they are not unnecessarily oppressive, that they do not lightly impinge on long established rights and freedoms, that there is some continuing public discourse with those affected by the ban, and that such limitations be open to reconsideration in the light of new information and new understanding.

Consideration of Ethical and Religious Perspectives

When the President asked NBAC to take up the issue of the cloning of human beings he admonished that "any discovery that touches upon human creation is not simply a matter of scientific inquiry, it is a matter of morality and spirituality as well." Although well aware that the United States Constitution prohibits the establishment of policies that are *solely* motivated by religious beliefs, NBAC shared the President's concern and sought out testimony about the cloning of human beings from leading scholars from a variety of religious traditions. In the same spirit NBAC also commissioned a background paper on the positions a number of religious traditions have taken or are considering on the cloning of human beings.

NBAC felt this was especially important because religious traditions influence and shape the moral views of many U.S. citizens and religious teachings over the centuries have provided an important source of ideas and inspiration. Although in a pluralistic society particular religious views cannot be determinative for public policy decisions that bind everyone, policy makers should understand and show respect for diverse moral ideas regarding the acceptability of cloning of human beings in this new manner.

Although some religious responses to the cloning of human beings through somatic cell nuclear transfer are tied tightly to particular scriptural texts or other faith commitments, often these ideas can be stated forcefully in terms understandable and persuasive to all persons, irrespective of specific religious beliefs. For example, appeal may be made to a view of human nature or of human reason, rather than exclusively to a religious source of knowledge such as scripture or revelation.

NBAC also wanted to determine whether various religious traditions, despite their distinctive sources of authority and argumentation, reach similar conclusions about this type of human cloning. A convergence of views across these traditions, as well as across secular traditions, would be instructive, even if not necessarily determinative, for public policy.

While many Americans look to their religious faiths for moral guidance on issues, other sources of moral knowledge and insight are also important. Many moral considerations that would be widely acknowledged as legitimate do not depend for their force on particular religious commitments or a specific philosophical outlook. For example, the conviction that it is wrong to harm a child is broadly shared among Americans. If you inquire why it is wrong to harm a child, people may give different answers. Some may refer to their religious convictions that a child is a gift from God. Others may say that it is always wrong to harm an innocent person without some compelling reason. To many people, this is a bedrock principle of ethics, even if it has no single,

universally acknowledged foundation in a specific religious or philosophical tradition. Rather, it finds its foundation in many different understandings of morality, some religious, some secular. Moral ideas such as the obligation not to inflict harm on others are accessible to all Americans and, therefore, can provide a robust foundation for public policy.

America has a vibrant tradition of ethical dialogue in which all are invited to participate. What moral considerations deserve our attention and which are the most important in responding to a particular issue? These are questions that arise with every new controversy. Whether one's ethical beliefs come from theological commitments, philosophical arguments, or from hard-won life experience, all voices should be welcome to the conversation, and all thoughtful views are entitled to a respectful hearing. While tolerance is a widely accepted virtue in American it is important to remind ourselves that it is built on the idea of mutual respect and the capacity to accept, whenever possible, the moral worth of others with whom one may disagree. Tolerance, therefore, means both agreeing to disagree and accepting the challenge of sustaining a community where moral authority will, to some extent, always be contested.

Policy makers, therefore, need to consider a range of moral views when they try to determine whether a particular policy is ethically justifiable as well as politically feasible. A particular policy may not be politically feasible, for instance, if it evokes thoughtful, widespread and vigorous moral opposition. In such circumstances its social costs may outweigh its putative benefits, and additional education and deliberation may be required before new policies are put in place.

Consideration of Law and Public Policy

The public policy chosen with respect to the cloning of human beings via somatic cell nuclear transfer should reflect a keen knowledge of the science, our best judgments about the ethics of attempting such an experiment, and our traditions regarding limitations on individual actions in the name of the common good. Americans in this era, relative to earlier generations, have a wide interest in and substantial knowledge of science. Nevertheless, in the weeks following the report of Dolly, the public, the media, and even some scientists demonstrated a surprising lack of understanding of the science involved in cloning. NBAC believes that public debate about issues such as human cloning requires an even more educated populace. Science policy has become public policy, which can be decided wisely only by an informed nation.

American tradition has been to avoid prohibiting or regulating personal activities, absent a compelling reason related to effects on others or society as a whole. Where the individual actions are expressions of fundamental rights, such as the right to free speech or the right to privacy, the reasons for limitation must be compelling, and the limitations made as minimal as possible.

The possibility of cloning human beings in this new fashion appears to raise concerns about direct physical harms to the children who may result. This in itself is sufficient to justify a

prohibition on such attempts at this time, even if such efforts were to be characterized as the exercise of a fundamental right to procreate. More speculative psychological harms to the child, and effects on the moral, religious, and cultural values of society may be enough to justify continued prohibitions in the future, but more time is needed for discussion and evaluation of these concerns.

In its discussion of potential policy options, NBAC considered the relative benefits of achieving an immediate prohibition through federal legislation on cloning human beings using somatic cell nuclear transfer techniques. It also considered more indirect means to deter such experiments.

Indirect, non-legislative options considered by NBAC include cooperation by the private sector, both research and clinical, in a moratorium on such experiments and/or clinical practice, and the continued prohibition of the use of federal funds to support such experiments. The American Medical Association, the World Medical Association, and the World Health Organization, for example, have already called for such a moratorium on clinical activities.

NBAC also weighed, in terms of nuclear transplantation cloning, the potential impact of a possible legislative measure to extend basic human subjects protections to all research conducted in the United States. This would insure that any research efforts to clone a human in this manner would, along with all other research using human subjects, be covered by the twin protections of informed consent and appropriate scientific review to insure an ethically acceptable balance between risks and benefits. In light of the early state of animal research in this area, such protections should prevent such cloning research from going forward at this time.

Finally, NBAC recognized that cooperation with other governments in the enforcement of any common elements of our respective policies could strengthen any of the measures adopted by the United States. Because science is a global endeavor, international cooperation would ensure consistency across borders and enhance public confidence in scientific research generally.

Process of NBAC and Organization of the Report

The results of NBAC's 90-day analysis are presented in this report. In its deliberations, NBAC focused its discussion on the science of the cloning of human beings using the somatic cell nuclear transfer technique, and the ethical, religious, legal, and regulatory implications of cloning human beings in this manner. To aid in these tasks NBAC invited testimony from an array of scientists, scientific societies, ethicists, theologians, and legal experts, and heard from a wide variety of interested parties during the public comment session at each meeting. In addition, it commissioned numerous background papers from recognized experts to inform its work.

This report consists of five chapters in addition to this one. Chapter Two describes the scientific developments that preceded and made possible the cloning of Dolly and speculates on potential applications of this and related technologies. Chapter Three presents some of the key

themes in religious interpretations and evaluations of human cloning. Chapter Four outlines the numerous ethical concerns raised by the prospect of cloning human beings via somatic cell nuclear transfer. Chapter Five discusses the legal and policy issues considered by the NBAC as it pondered various recommendations. The final section, Chapter Six, presents the recommendations made by NBAC in response to the President's request.

In many instances, NBAC found itself moving at a rapid pace in only partly charted waters. In those times it relied on its individual and collective wisdom, judgment, and moral foundations, and the advice of others. NBAC argued and debated the issues as it searched for appropriate formulations of the problem and for the wisdom to suggest useful policy options. While the members of NBAC learned a great deal during its deliberations, we could not reach a resolution on all of the issues before us. Nevertheless, it was able to accomplish two things. First, it developed a set of recommendations, which are set out in Chapter Six. Second, it agreed that it was important to take a number of steps to ensure the continuation of an informed national discussion of these issues and other developments in the biomedical sciences and clinical practices that have an impact on our moral lives and cultural traditions.

References

- Blank, R.H., *The Political Implications of Human Genetic Technology* (Boulder, CO: Westview Press, 1981).
- Davis, B.D., "Three specters: Dangerous products, powers, or ideas," in *Genetics and the Law II*, A. Milunsky and G.J. Annas (eds.) (New York: Plenum Press, 1980).
- Di Bernadino, M.A., *Genomic Potential of Differentiated Cells* (New York: Columbia University Press, 1997).
- Fredrickson, D.S., "Asilomar and recombinant DNA: The end of the beginning," in *Biomedical Politics*, K.E. Hanna (ed.) (Washington, D.C.: National Academy Press, 1991).
- Institute of Medicine, *Fetal Research and Applications: A Conference Summary* (Washington, D.C.: National Academy Press, 1994).
- Lederberg, J., "Experimental genetics and human evolution," *The American Naturalist* 100:519-531, 1966.
- Macklin, R., "Splitting embryos on the slippery slope: Ethics and public policy," *Kennedy Institute of Ethics Journal* 4(3)209-225, 1994.
- Macklin, R., Testimony before the National Bioethics Advisory Committee, Washington, D.C., March 14, 1997.
- National Institutes of Health, *Report of the Human Embryo Research Panel* (Bethesda, MD: National Institutes of Health, 1994).
- Office of Technology Assessment, *New Developments in Biotechnology: Ownership of Human Tissues and Cells*, OTA-BA-337 (Washington, D.C.: U.S. Government Printing Office, 1987).
- Office of Technology Assessment, *The Regulatory Environment for Science* (Washington, D.C.: U.S. Government Printing Office, 1986).

Chapter Two

THE SCIENCE AND APPLICATION OF CLONING ⁴

The report in February 1997 that scientists in Scotland had cloned a sheep, Dolly, led to much public discussion of "cloning" of animals and speculation about the possibility of cloning humans. The term "cloning" is used by scientists to describe many different processes that involve making duplicates of biological material. In most cases isolated genes or cells are duplicated for scientific study, and no new animal results. This type of cloning, using genes and cells, has led to many medical advances such as providing insulin to treat diabetes and therapies for hemophilia. The sheep experiment was different; it used a cloning technique called "somatic cell nuclear transfer" and resulted in an animal that was a genetic twin—although delayed in time—of an adult sheep. This technique of transferring a nucleus from a somatic cell into an egg that produced Dolly was an extension of experiments that had been ongoing for over 40 years. These experiments were aimed at understanding how development of an animal from a single fertilized egg is carried out. In recent years the agricultural industry has been trying to improve nuclear transplantation cloning to facilitate the breeding of desirable livestock and some biotechnology companies are exploring ways to use nuclear transfer cloning to improve the production of therapeutic drugs. In addition to drug production, understanding the details of nuclear transplantation cloning might lead to new therapies to treat human disease. For instance it might be possible to grow human cells and tissues for transplantation and grafts that would not be rejected after transfer, as they often are today. These kinds of benefits are currently only hypothetical and much additional research will be needed in animal systems. Although the birth of Dolly was lauded as an amazing success, in fact the procedure is not perfected. Only one sheep was produced from over two hundred nuclear transfers. In addition, it is not yet clear whether Dolly is normal or whether she could have subtle problems that might lead to serious diseases. Using this technique to produce a human child might result in, for example, malformations or disease due to problems inherent in the technique. Thus, while using animals to understand the biological process that produced Dolly holds great promise for future medical advances, there is no current scientific justification for attempting to produce a human child at this time with this technique.

What is Cloning?

The word clone is used in many different contexts in biological research but in its most simple and strict sense, it refers to a precise genetic copy of a molecule, cell, plant, animal, or human being. In some of these contexts, cloning refers to established technologies that have been part of

⁴ Much of this chapter is derived from the material contained in two commissioned papers provided by Janet Rossant, Samuel Lunenfeld Research Institute, Mount Sinai Hospital, Toronto; and by Stuart Orkin, Children's Hospital and Dana Farber Cancer Institute, Boston.

agricultural practice for a very long time and currently form an important part of the foundations of modern biological research.

Indeed, genetically identical copies of whole organisms are commonplace in the plant breeding world and are commonly referred to as “varieties” rather than clones. Many valuable horticultural or agricultural strains are maintained solely by vegetative propagation from an original plant, reflecting the ease with which it is possible to regenerate a complete plant from a small cutting. The developmental process in animals does not usually permit cloning as easily as in plants. Many simpler invertebrate species, however, such as certain kinds of worms, are capable of regenerating a whole organism from a small piece, even though this is not necessarily their usual mode of reproduction. Vertebrates have lost this ability entirely, although regeneration of certain limbs, organs, or tissues can occur to varying degrees in some animals.

Although a single adult vertebrate cannot generate another whole organism, cloning of vertebrates does occur in nature, in a limited way, through multiple births, primarily with the formation of identical twins. However, twins occur by chance in humans and other mammals with the separation of a single embryo into halves at an early stage of development. The resulting offspring are genetically identical, having been derived from one zygote, which resulted from the fertilization of one egg by one sperm.

At the molecular and cellular level, scientists have been cloning human and animal cells and genes for several decades. The scientific justification for such cloning is that it provides greater quantities of identical cells or genes for study; each cell or molecule is identical to the others.

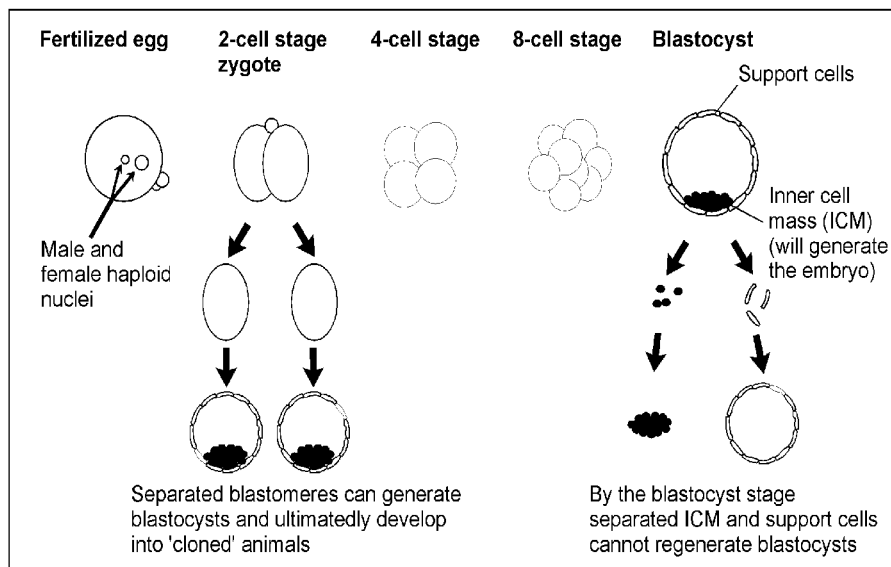
At the simplest level, molecular biologists routinely make clones of deoxyribonucleic acid (DNA), the molecular basis of genes. DNA fragments containing genes are copied and amplified in a host cell, usually a bacterium. The availability of large quantities of identical DNA makes possible many scientific experiments. This process, often called *molecular cloning*, is the mainstay of recombinant DNA technology and has led to the production of such important medicines as insulin to treat diabetes, tissue plasminogen activator (tPA) to dissolve clots after a heart attack, and erythropoietin (EPO) to treat anemia associated with dialysis for kidney disease.

Another type of cloning is conducted at the cellular level. In *cellular cloning* copies are made of cells derived from the soma, or body, by growing these cells in culture in a laboratory. The genetic makeup of the resulting cloned cells, called a cell line, is identical to that of the original cell. This, too, is a highly reliable procedure, which is also used to test and sometimes to produce new medicines such as those listed above. Since molecular and cellular cloning of this sort does not involve germ cells (eggs or sperm), the cloned cells are not capable of developing into a baby.

The third type of cloning aims to reproduce genetically identical animals. Cloning of animals can typically be divided into two distinct processes, *blastomere separation* and *nuclear transplantation cloning*.

In blastomere separation, the developing embryo is split very soon after fertilization when it is composed of two to eight cells (see figure 1). Each cell, called a blastomere, is able to produce a new individual organism. These blastomeres are considered to be totipotent, that is they possess the total potential to make an entire new organism. This totipotency allows scientists to split animal embryos into several cells to produce multiple organisms that are genetically identical. This capability has tremendous relevance to breeding cattle and other livestock.

Figure 1. Preimplantation embryo development in mammals



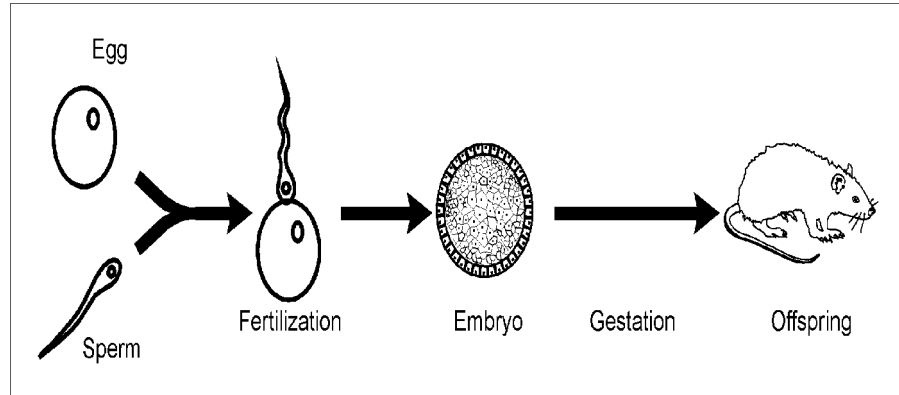
In the 1980s, a sophisticated cloning

developed, known as nuclear transplantation cloning. The nucleus of somatic cells is diploid—that is, it contains two sets of genes, one from the mother and one from the father. Germ cells, however, contain a haploid nucleus, with only the maternal or paternal genes. In nuclear transplantation cloning, the nucleus is removed from an egg and replaced with the diploid nucleus of a somatic cell. In such nuclear transplantation cloning there is a single genetic "parent," unlike sexual reproduction where a new organism is formed when the genetic material of the egg and sperm fuse (see figure 2). The first experiments of this type were successful only when the donor cell was derived from an early embryo. In theory, large numbers of genetically identical animals could be produced through such nuclear transplantation cloning. In practice, the nuclei from embryos which have

the early more —ed form of animals was

developed beyond a certain number of cells seem to lose their totipotency, limiting the number of animals that can be produced in a given period of time from a single, originating embryo.

Figure 2. Sexual reproduction



The new development in the experiments that Wilmut and colleagues carried out to produce Dolly was the use of much more developed somatic cells isolated from adult sheep as the source of the donor nuclei. This achievement of gestation and live birth of a sheep using an adult cell donor nucleus was stunning evidence that cell differentiation and specialization are reversible. Given the fact that cells develop and divide after fertilization and differentiate into specific tissue (e.g., muscle, bone, neurons), the development of a viable adult sheep from a differentiated adult cell nucleus provided surprising evidence that the pattern of gene expression can be reprogrammed. Until this experiment many biologists believed that reactivation of the genetic material of mammalian somatic cells would not be complete enough to allow for the production of a viable adult mammal from nuclear transfer cloning.

The Science That Led to Dolly

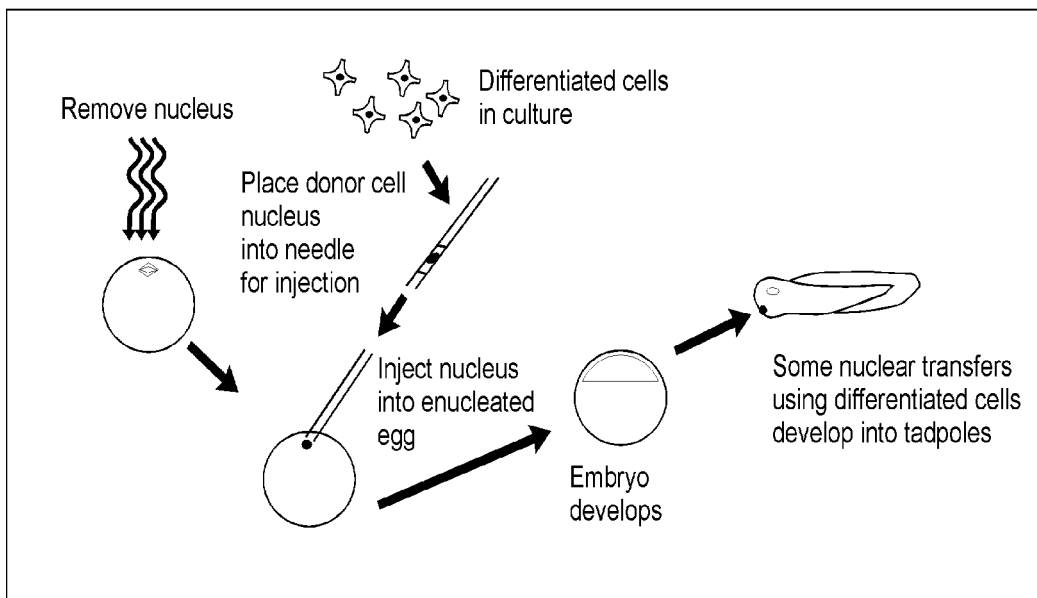
Until the birth of Dolly, developmental and molecular biologists focused their efforts on understanding the processes of cellular differentiation, the regulation of genes during this process, the factors that stimulate differentiation, and the reversibility of this process. Biologists have investigated whether, once cellular differentiation occurs, the process is reversible. These questions have by no means been fully answered by the appearance of Dolly. If anything, the existence of Dolly stimulates even more speculation and inquiry. This section describes the background of the science that led to the birth of the cloned sheep, including early studies of differentiation and development, research on regulation of gene expression, experiments using nuclear transfer in animals, and studies of cell programming and division.

Early Studies of Differentiation and Development

Nearly every cell contains a spheroid organelle called the nucleus which houses nearly all the genes of the organism. Genes are composed of DNA, which serve as a set of instructions to the cell to produce particular proteins. Although all somatic cells contain the same genes in the nucleus, the particular genes that are activated vary by the type of cell. For example, a differentiated somatic cell, such as a neuron, must keep a set of neural-specific genes active and silence those genes specific to the development and functioning of other types of cells such as muscle or liver cells.

Investigations which began over 40 years ago sought to determine whether a differentiated somatic cell still contained all genes, even those it did not express. Early experiments in frogs and toads by Gurdon (1962) and by Briggs and King (1952) provided strong evidence that the expression potential of the genes in differentiated cells is essentially unchanged from that of the early embryo. Nuclei from donor differentiated cells were injected into recipient eggs in which the nucleus had been inactivated (figure 3). The first series of experiments used cells from tadpoles as the source of donor nuclei (Gurdon, 1962) and adult frogs were produced, albeit at a very low efficiency. Although the cells used were highly specialized, they were not derived from the adult frog, so the cells might not have been fully differentiated.

Figure 3. Nuclear transfer carried out in frogs



In these experiments, because isolated nuclei were used, other cellular components were not transferred to the recipient egg. Among those other cellular components is an organelle called the mitochondrion, the energy-producing component of the cell. Although most of the genes specifying this cellular component reside in the nucleus, the mitochondrion itself houses some of its own genes. Thus, in somatic cell nuclear transfer, mitochondrial genes are not transferred to the enucleated egg along with the nuclear genes. Because there are some serious diseases associated with mitochondrial genes, nuclear transplantation could allow an embryo to develop with new, healthy mitochondria from a donor.

Gurdon and colleagues performed another carefully controlled series of experiments in which they used nuclei from adult frog skin cells for transfer to an enucleated egg (Gurdon, et al., 1975). Four percent of the nuclei transferred eventually gave rise to fully developed tadpoles. These experiments provided evidence that the genes contained in the nuclei of differentiated cells could be reactivated by the cytoplasm of the egg and thus direct normal development, but only up to a certain stage. No viable adult frog ever developed from these tadpoles and there was a decrease in the number of tadpoles born as the age of the transferred nucleus increased. This left open the possibility that complete reactivation of the adult nucleus was prevented by some irreversible change in the genetic material, and that there was a progressive decline in nuclear potential with age.

Careful analysis, however, suggested that the major reason for developmental failure of the transplanted embryos appeared to be chromosomal abnormalities that occurred during the process of nuclear transplantation itself. The rate of cell division of adult cells is much slower than that of the cells of the early frog embryo. Thus, in reality, for this technique to work it would be necessary that the transplanted adult nucleus reprogram its gene expression, replicate its DNA, and enter the normal embryonic cell division cycle within an hour of nuclear transfer. It is remarkable, given the mechanics and timing of the process, that any nuclei from adult somatic cells were successful in generating an embryo. Although they did not produce normal adult animals, the amphibian nuclear transfer experiments of Gurdon and others succeeded in demonstrating that the differentiated state of adult somatic cells do not involve major irreversible changes in their DNA.

Regulation of Gene Expression

In recent years, it has been determined that most patterns of differentiated gene expression are maintained by active control mechanisms, in which particular genes are turned on or off by regulatory proteins (Blau, 1992). Further studies suggested that it might be possible to reprogram the gene expression of somatic cells so that they perform a different task. The role of a particular cell type (e.g., muscle, liver, or skin) depends on the combination of regulatory proteins it expresses. While in certain specialized cells, such as white blood cells, actual rearrangements and deletions of DNA occur, for the most part, however, gene expression is not regulated by the loss of DNA but by the turning off of specific genes. Thus, it should be possible to activate or inactivate almost any gene in a cell, given the right cellular environment containing the appropriate regulatory molecules.

To reprogram the gene expression of a somatic cell it is not essential to fuse it with an egg; in some cases re-programming can occur through fusion of two adult cells. Cell fusion experiments, in which different somatic cell types are fused, have demonstrated that extensive reprogramming of differentiated nuclei can occur. For example, when muscle cells are fused with non-muscle cells of various sorts, muscle-specific genes are activated in the non-muscle cells (Blau et al., 1985), and, similarly, genes that code for hemoglobin can be activated in many cell types after fusion with red blood cells (Baron and Maniatis, 1986). These and other kinds of experiments have led to the isolation of specific factors that regulate cell differentiation, such as the gene that regulates the formation of muscle cells (Weintraub, 1993).

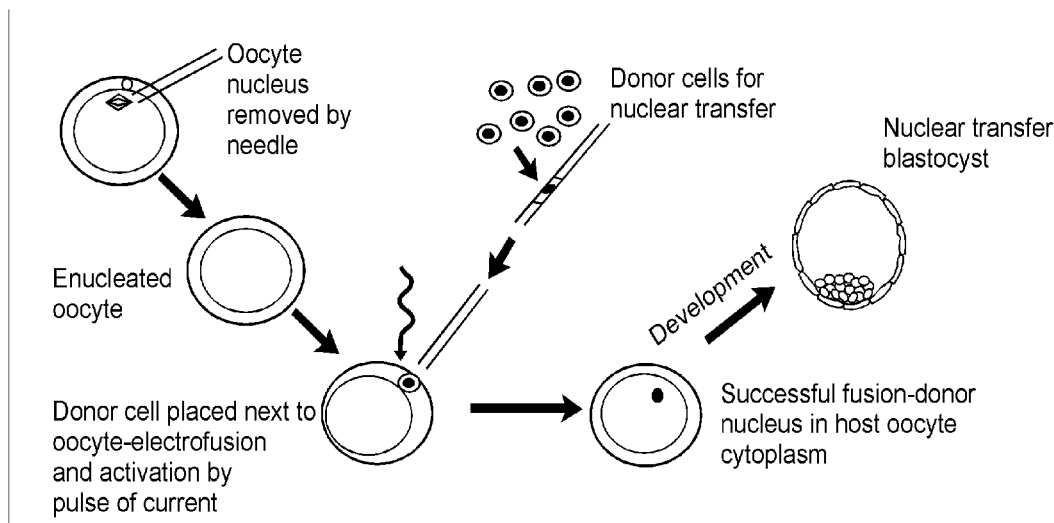
These studies have further demonstrated that the stability of the differentiated state is not absolute. Thus, given the appropriate regulatory molecules and enough time to reprogram an adult nucleus, somatic cells can re-initiate earlier programs of differentiation.

Nuclear Transfer in Mammals

Experiments in mammals have also suggested that it is possible to reprogram adult somatic cells. Following success in the nuclear transfer experiments in frogs, scientists attempted to repeat the experiments in mice. It was known that early development occurs at a considerably slower rate in mammals than amphibians, giving hope that reprogramming of the donor nucleus would occur more efficiently. For example, the first cell division in mice occurs about a day after fertilization, giving ample time, it was thought, for the reprogramming of gene expression and adjustment of the cell division cycle. This proved not to be the case. Early experiments showed that nuclei from somatic cells fused with fertilized eggs did not undergo nuclear division (Graham, 1969).

However, a series of experiments in mice in the mid 1980s showed that nuclei could be successfully exchanged between fertilized eggs, with 90 percent reaching the blastocyst stage of embryonic development and beyond (McGrath and Solter, 1984). Nuclei recovered and transplanted from embryos at the two-cell stage could direct development to the blastocyst stage. Nuclei transferred from embryos at later stages, however, could not successfully recapitulate development. In fact, in mice, nuclei show less totipotency than whole cells. Many experiments have shown that blastomeres up to the early blastocyst stage are still totipotent when combined with other embryonic cells (Rossant and Pedersen, 1986). This means that the failure of nuclear reprogramming has to be the result of something other than irreversible changes to the genetic material of the cells. In 1986, Willadsen reported experiments with sheep. Unlike the situation in mice, enucleated eggs from sheep could be fused with blastomeres taken from embryos at the eight-cell stage to provide donor nuclei and viable offspring were produced (Willadsen, 1986).

Figure 4. Nuclear transfer via electrofusion in mammals



Recent experiments have used nuclear transfer into enucleated unfertilized eggs (figure 4). Using these very early stage eggs prolongs the period of possible reprogramming before the donor nucleus has to undergo the first division. And the advent in the last few years of electrofusion for both fusion of cells and activation of the egg has been another major advance, because activation and fusion occur simultaneously. Because these experiments use fusion of two cells and not simple injection of an isolated nucleus, all of the cellular components are transferred. Thus, the mitochondria, which contain some genes of their own, are transferred along with the nucleus. Because an enucleated egg also contains mitochondria, the result of a fusion experiment is a cell with a mixture of mitochondria from both the donor and the recipient. Since the mitochondrial genes represent an extremely small proportion of the total number of mammalian genes, mixing of mitochondria per se is not expected to have any major effects on the cell. However, if the nucleus donor suffers from a mitochondrial disease, and the egg donor does not, then mixture of the mitochondria may significantly alleviate the disease.

Over the past ten years or so there have been numerous reports of successful nuclear transfer experiments in mammals, nearly all of them using cells taken directly from early embryos. The oldest embryonic nucleus that can successfully support development differs among species. Four-cell blastomere nuclei have been successfully used in pigs (Prather, et al., 1989). In mice, no nucleus older than the eight-cell stage has been used successfully (Cheong, et al., 1993). In rabbits, 32- to 64-cell early embryos can be used as nuclear donors (Yang, et al., 1992). In cows and sheep, cells from what is called the inner cell mass (ICM) of the 120-cell blastocyst stage (see figure 1) have been used successfully (Collas and Barnes, 1994; Smith and Wilmut, 1989). Indeed, in both cows and sheep, cell lines have been made from these ICM cells and nuclei from these cells have been used to reprogram development after transfer into enucleated unfertilized eggs.

In the first experiments of this sort by Sims and First (1994), cow cells derived from embryos were grown in the laboratory for up to 28 days, and then used as nuclear donors, without any attempt at synchronization of the cell division cycle of the donor cells. Of those successfully fused with eggs, 24 percent developed to the blastocyst stage, and 4/34 (12 percent) of the blastocysts transferred to recipient cows developed into normal calves. This success rate compares favorably with those seen using earlier blastomeres and suggests that it might be possible to achieve successful nuclear transfer from permanent cell lines established from early embryos.

Reprogramming of Nuclei and Synchronization of the Cell Division Cycle

There has been some study of the events that occur once a transferred nucleus is exposed to the cytoplasm of the egg and some, but not all, of the parameters that affect success of nuclear transfer are known (Fulka, et al., 1996). Enucleated eggs used for fusion only proceed to division after activation by some artificial signal, such as the electrical current used in the electrofusion technique. When donor nuclei are introduced into the enucleated egg, they usually undergo DNA replication, nuclear envelope breakdown, and chromosome condensation. After activation of the egg the nuclear envelope is reformed around the donor chromosomes. The nucleus now takes on the appearance of a typical egg nucleus at this stage, which is large and swollen. It is assumed that this process begins the reprogramming of the transferred donor nucleus by exposing the chromosomes to the egg cytoplasm and beginning the exchange of egg-derived proteins for the donor nucleus' own proteins (Prather and First, 1990).

It is not clear whether exposure to proteins found in the earliest stages of development and/or nuclear swelling is a prerequisite for reprogramming for later development. Experiments in a number of species have shown that, when nuclei are fused with eggs that have been activated some hours prior to fusion, no DNA replication, chromosome condensation, or nuclear swelling occurs, but normal development can transpire (Campbell, et al., 1994; Stice, et al., 1994).

Once again, it is not obvious which of the processes described above are required for normal development. In rabbits, cows, sheep, and mice (Cheong, et al., 1993; Collas, et al., 1992) experiments have shown that nuclei from cells in the early phases of the cell division cycle do better than cells in later stages. In the first phase of the cell cycle, termed G1 (for Gap phase 1), cells contain only one complete set of chromosomes and are relatively quiescent. They then enter a period of DNA synthesis or replication, called S-phase, followed by a rest phase, called G2 (Gap phase 2), at which time they each have a duplicate copy of each chromosome. This doubling of the chromosomes is in preparation for cell division where an equal number will be divided between the two daughter cells. Because DNA replication is induced *after* nuclear transfer, any nucleus that has initiated replication *before* transfer will end up with too much DNA, which will likely result in chromosome anomalies. Thus, the need to transfer nuclei in the G1 phase before replication is initiated, is likely to be important to avoid chromosome damage that will prevent development of the embryo into a viable offspring.

Changes in Technique that Allowed for the Birth of Dolly

In background work that preceded the birth of Dolly, Wilmut and colleagues established cell lines from sheep early embryos, or blastocysts, and used these cells as nuclear donors (Campbell, et al., 1996). In an attempt to avoid the problems of nuclear transfer of non-G1 nuclei into activated eggs, they starved the donor cell line by removing all nutrients from the medium prior to nuclear transfer. Under these starvation conditions, the cells exit the cell cycle and enter the so-called “G0” state (Gap phase 0), similar to the G1 phase in which chromosomes have not replicated. Fusion of G0 nuclei with eggs ensures that the donor chromosomes have not initiated replication prior to fusion. It was also suggested that the G0 state might actually increase the capacity of the nucleus to be reprogrammed by the egg cytoplasm. However, there is currently no direct evidence to support this, nor to conclude that nuclei synchronized in the G0 stage are any better than nuclei synchronized in G1. For Wilmut and colleagues, approximately 14 percent of fusions resulted in development of blastocysts, and 4/34 (12 percent) embryos transferred developed into live lambs. Two died shortly after birth. The success rate in sheep and cow experiments was almost identical, and suggests that division of cells in culture for many days does not inhibit the ability of their nuclei to be reprogrammed by the egg environment. Could the same be true of nuclei from fully differentiated somatic cells?

All of this background work led up to Dolly (Wilmut, et al., 1997). Wilmut and colleagues took late embryo, fetal cell cultures, and cell cultures derived from the mammary gland of an adult sheep and applied the same approach of synchronizing the cells in the G0 stage prior to nuclear transfer. They reported successful production of live offspring from all three cell types, although only 29 of 277 (11 percent) of successful fusions between adult mammary gland nuclei and enucleated oocytes developed to the blastocyst stage, and only 1 of 29 (3 percent) blastocysts transferred developed into a live lamb. This experiment was, in fact, the first time any fully developed animal had been born following transfer of a somatic cell nucleus, since the earlier frog experiments only generated tadpoles.

It should be noted, however, that the amount of new information regarding the stability of the differentiated state derived from this experiment is small, as no attempt was made to document that the donor cells were fully differentiated cells, the genes of which expressed specialized mammary gland proteins. In the earlier experiments with frogs, the fact that the donor cells were fully differentiated was documented in such a manner. In the present case, Dolly could have been derived from a less-differentiated cell in the population, such as a mammary stem cell.

Remaining Scientific Uncertainties

Several important questions remain unanswered about the feasibility in mammals of nuclear transfer cloning using adult cells as the source of nuclei:

First, can the procedure that produced Dolly be carried out successfully in other cases? Only one animal has been produced to date. Thus, it is not clear that this technique is reproducible even in sheep.

Second, are there true species differences in the ability to achieve successful nuclear transfer? It has been shown that nuclear transfer in mice is much less successful than in larger domestic animals. Part of this difference may reflect the intensity of research in this area in the last ten years; agricultural interests have meant that more nuclear transfer work has been performed in domestic animals than in mice. But part of the species differences may be real and not simply reflect the greater recent effort in livestock. For example, in order for a differentiated nucleus to redirect development in the environment of the egg, its constellation of regulatory proteins must be replaced by those of the egg in time for the embryo to use the donor nucleus to direct normal development of the embryo. The species difference may be the result of the different times of embryonic gene activation.

In mammals, unlike many other species, the early embryo rapidly activates its genes and cannot survive on the components stored in the egg. The time at which embryonic gene activation occurs varies between species—the late 2-cell stage in mice (Schultz, 1993), the 4-8 cell stage in humans (Braude, et al., 1988) and the 8-16 cell stage in sheep. The later onset of embryonic gene activation and transcription in sheep provides an additional round or two of cell divisions during which nuclear reprogramming can occur, unlike the rapid genome activation in the mouse. Further cross-species comparisons are needed to assess the importance of this difference in the time of genome activation for the success of nuclear transfer experiments. In humans, for example, the time period before gene activation is very short, which might not permit the proper reprogramming of genes after nuclear transfer to allow for subsequent normal development.

Third, will the phenomenon of genetic imprinting affect the ability of nuclei from later stages to reprogram development? In mammals imprinting refers to the fact that the genes inherited on the chromosomes from the father (paternal genes) and those from the mother (maternal genes) are not equivalent in their effects on the developing embryo (Solter, 1988). Some heritable imprint is established on the chromosomes during the development of the egg and the sperm such that certain genes are expressed only when inherited from the father or mother. Imprinting explains why parthenogenetic embryos, with only maternally inherited genes, and androgenetic embryos, with only paternally inherited genes, fail to complete development (Fundele and Surani, 1994). Nuclei transferred from diploid cells, whether embryonic or adult, should contain maternal *and* paternal copies of the genome, and thus not have an imbalance between the maternally and paternally derived genes.

The successful generation of an adult sheep from a somatic cell nucleus suggests that the imprint can be stable, but it is possible that some instability of the imprint, particularly in cells in culture, could limit the efficiency of nuclear transfer from somatic cells. It is known that disturbances in imprinting lead to growth abnormalities in mice and are associated with cancer and rare genetic conditions in children.

Fourth, will cellular aging affect the ability of somatic cell nuclei to program normal development? As somatic cells divide they progressively age and there is normally a defined number of cell divisions that they can undergo before senescence. Part of this aging process

involves the progressive shortening of the ends of the chromosomes, the telomeres, and other genetic changes. Germ cells (eggs and sperm) evade telomere shortening by expressing an enzyme, telomerase, that can keep telomeres full length. It seems likely that returning an adult mammalian nucleus to the egg environment will expose it to sufficient telomerase activity to reset telomere length, since oocytes have been found to be potent sources of telomerase activity (Mantell and Greider, 1994).

Fifth, will the mutations that accumulate in somatic cells affect nuclear transfer efficiency and lead to cancer and other diseases in the offspring? As cells divide and organisms age, mistakes and alterations (mutations) in the DNA will inevitably occur and will accumulate with time. If these mistakes occur in the sperm or the egg, the mutation will be inherited in the offspring. Normally mutations that occur in somatic cells affect only that cell and its descendants which are ultimately dispensable. Nevertheless, such mutations are not necessarily harmless. Sporadic somatic mutations in a variety of genes can predispose a cell to become cancerous. Transfer of a nucleus from a somatic cell carrying such a mutation into an egg would transform a sporadic somatic mutation into a germline mutation that is transmitted to all of the cells of the body. If this mutation were present in all cells may lead to a genetic disease or cancer. The risks of such events occurring following nuclear transfer are difficult to estimate.

Why Pursue Animal Cloning Research?

Research on nuclear transfer cloning in animals may provide information that will be useful in biotechnology, medicine, and basic science. Some of the immediate goals of this research are:

- to generate groups of genetically identical animals for research purposes
- to rapidly propagate desirable animal stocks
- to improve the efficiency of generating and propagating transgenic livestock
- to produce targeted genetic alterations in domestic animals
- to pursue basic knowledge about cell differentiation

Cloning Animals for Research Purposes

Inbred strains of mice have been a mainstay of biological research for years because they are essentially genetically identical and homozygous (i.e., both copies of each gene inherited from the mother and father are identical). Experimental analysis is simplified because differences in genetic background that often lead to experimental variation are eliminated. Generating such homozygous inbred lines in larger animals is difficult and time consuming because of the long gestation times and small numbers of offspring. The concept of generating small groups of identical animals by nuclear transfer has been proposed as an alternative strategy to obtaining a genetically identical group of animals, and apparently underlies a recent report from Oregon on successful nuclear transfer from early embryonic nuclei in rhesus macaque monkeys (Weiss and Schwartz, 1997).

Repeated cycles of nuclear transfer can expand the number of individual animals derived from one donor nucleus, allowing more identical animals to be generated. The first nuclear transfer embryo is allowed to divide to early blastomere stages and then those cells are used as donor nuclei for another series of transfers. This process can be carried on indefinitely, in theory, although practice suggests that successful fusion rates decline with each cycle of transfer. One experiment in cows, for example, produced 54 early embryos after three cycles of transfer from a single blastomere nucleus from one initial embryo (Stice and Keefer, 1993). Viable calves were produced from all three cycles of nuclear transfer.

This approach is likely to be limited in its usefulness, however. A group of cloned animals derived from nuclear transfer from an individual animal is self-limited. Unless they are derived from an inbred stock initially, each clone derived from one individual will differ genetically from a clone derived from another individual. Once a cloned animal is mated to produce offspring, the offspring will no longer be identical due to the natural processes which shuffle or recombine genes during development of eggs and sperm. Thus each member of a clone has to be made for each experiment by nuclear transfer, and generation of a large enough number of cloned animals to be useful as experimental groups is likely to be prohibitively expensive in most animals.

Advantages of Nuclear Transfer Cloning for Breeding Livestock

In animal breeding, the rapid spread of certain traits within stocks of domestic animals is of obvious commercial importance and has very long historical standing. Artificial insemination and embryo transfer can increase the effective reproductive output of individual elite male and female animals and are widely used in the livestock industry. Nuclear transfer cloning, especially from somatic cell nuclei, could provide an additional means of expanding the number of chosen livestock. The ability to make identical copies of adult prize cows, sheep, and pigs is a feature unique to nuclear transfer technologies, and may well be used in livestock production, if the efficiencies of adult nuclear transfer can be improved. The net effect of multiplying chosen animals by cloning will be to reduce the overall genetic diversity in a given livestock line, likely with severe adverse long-term consequences. If this technique became widespread, efforts would have to be made to ensure a pool of genetically diverse animals for future livestock maintenance.

Improved Generation and Propagation of Transgenic Livestock

There is considerable interest in being able to genetically alter farm animals by introduction and expression of genes from other species, such as humans. So-called "transgenic animals" were first developed using mice, by microinjection of DNA into the nucleus of the egg. This ability to add genes to an organism has been a major research tool for understanding gene regulation and for using the mouse as a model in studies of certain human diseases. It has also been applied to other species including livestock. Proposed applications of this technology to livestock improvement include the possible introduction of growth-enhancing genes, genes that affect milk quality or wool fibers, or disease-resistance genes (Ward and Nancarrow, 1995). But progress has been slow. Initial results of the manipulation of meat production by expression of excess growth hormone in pigs led to undesirable side effects (Pursel, et al., 1989).

Currently, the major activity in livestock transgenesis is focused on pharmaceutical and medical applications. The milk of livestock animals can be modified to contain large amounts of pharmaceutically important proteins such as insulin or factor VIII for treatment of human disease by expressing human genes in the mammary gland (Houdebine, 1994). In sheep greater than 50 percent of the proteins in milk can be the product of a human gene (Colman, 1996). The milk of even transgenic mice can yield large (milligram) quantities of recombinant proteins. Since many such proteins are active at very low concentrations, it is estimated that production of human drugs from transgenic animals could be considerably more cost-effective than current methods.

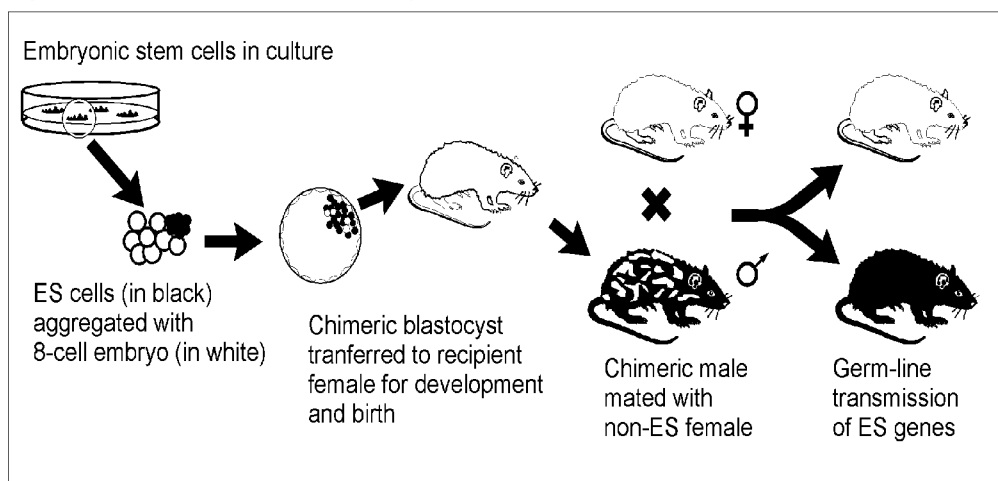
Another major area of interest is the use of transgenic animals for organ transplantation into humans. Pig organs, in many cases, are similar enough to humans to be potentially useful in organ transplants, if problems of rejection could be overcome. Rejection can already be partly overcome by the expression of human complement (a component of the immune system) regulatory proteins in transgenic pigs. Further transgenic manipulation such as the expression of human antigens in pigs could alleviate organ shortages by minimizing or eliminating the rejection of pig organs transplanted into humans, although other barriers, such as the possible transmission of viruses from pigs to humans, must be overcome.

However the current method of directly injecting genes into fertilized eggs is inefficient. Not all injected eggs will develop into transgenic animals, and then not all transgenic animals will express the added gene in the desired manner. The production of transgenic livestock is slow and expensive. Nuclear transfer would speed up the expansion of a successful transgenic line, but, perhaps more importantly, it would allow more efficient generation of transgenic animals in the first place. Foreign DNA, such as a human gene, could be introduced into cell lines in culture and cells expressing the transgene could be characterized and used as a source of donor nuclei for cloning, and all offspring would likely express the human gene. This, in fact, was the motivation behind the experiments that led to the production of Dolly. If a human gene such as that for insulin could be expressed in the mammary gland, the milk of the sheep would be an excellent source of insulin to treat diabetes.

Generating Targeted Gene Alterations

The most powerful technology for gene replacement in mammals was developed in mice. This technique adds manipulated or foreign DNA to cells in culture to replace the DNA present in the genome of the cells. Thus mutations or other alterations that would be useful in medical research can be introduced into an animal in a directed and controlled manner and their effects studied, a process called *gene targeting* (Capecchi, 1989). This technology would be of limited use, however, without some means of taking the changes generated in cultured cells and reintroducing them into animals. In mice, this can be achieved by the use of embryonic stem (ES) cells that are capable of being cultured indefinitely in the undifferentiated state. ES cells retain the potential to form all cells of the animal, including the germ cells, when returned to the environment of the early embryo (figure 5). As the technique is currently used in mice, the first generation of animals generated from the ES cells are "chimeric," that is they are made up of a mixture of cells from two different animals. These mice must then be bred one more time to transmit altered genes to the next generation. Using this technique, any genetic alteration made in the embryonic stem cells in culture can be introduced back into mice (Robertson, 1986).

Figure 5. Generation of mice from embryonic stem cells

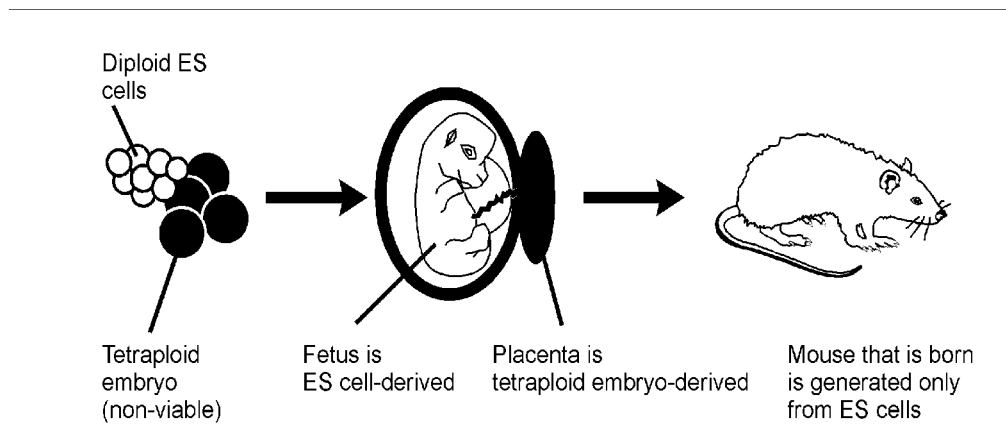


This use of gene replacement and embryonic stem cell technology has been responsible for the explosion in the generation of "knock-out" mice, in which specific genes have been deleted from the genome. These mice have been invaluable in current studies to understand normal gene function and to allow the generation of accurate models of human genetic disease. Gene targeting approaches can also be used to ensure correct tissue-specific expression of foreign genes and to suppress the expression of genes in inappropriate tissues. If applied to domestic animals, this technology could increase the efficiency of the expression of foreign genes by targeting the introduced genes to appropriate regions of the chromosome. It could also be used to directly alter the normal genes of the organism, which could influence animal health and productivity or to help

develop transgenic organs that are less likely to be rejected upon transplantation. However, to date, there are no fully validated embryonic stem cell lines in domestic animals. Nuclear transfer from somatic cell lines into an egg, as reported by Wilmut and colleagues, provides a possible alternative to the embryonic stem cell route for introduction of targeted gene alterations into the germ line of animals.

Apart from the fact that embryonic stem cell lines have not yet been produced from farm animals, the other argument for using nuclear transfer to introduce germ line genetic alterations in farm animals is that it eliminates one generation of breeding from the initial chimeric animals. This is an important time and cost saving factor in farm animals with long generation times and small litter size. However this factor might not be as important as once thought. In mice, it turns out, embryonic stem cells can also be used to generate cloned animals carrying gene alterations directly without the initial generation of chimeric animals. When 'tetraploid' embryos that are not themselves capable of developing normally are used as the host cells, the entire mouse fetus can be derived directly from the normal diploid ES cells (figure 6)(Nagy, et al., 1993). Although this procedure is not yet very efficient, it illustrates the remarkable properties of ES cells and suggests that similar approaches could be applied in other species such as farm animals.

Figure 6. Mice can be generated directly from ES cells without first generating a chimera



Basic Research on Cell Differentiation

The basic cellular processes that allowed the birth of Dolly by nuclear transfer using the nucleus from an adult somatic donor cell are not well understood. If indeed the donor cell was a fully differentiated cell and not a rare, less differentiated stem cell that resulted in this cloned sheep, there will be many questions to ask about how this process occurred. How the specialized cell from the mammary gland was reprogrammed to allow the expression of a complete developmental program will be a fascinating area of study. Developmental biologists will want to know which genes are reprogrammed, when they are expressed, and in what order. This might

shed light on the still poorly understood process of sequential specialization that must occur during development of all organisms.

Molecular biologists will also likely learn much from studying how reprogramming and reactivation occurred. What regulatory proteins in the host egg participated in the reprogramming? How did these proteins interact with each other and the DNA so that inactive genes from the mammary gland cells might be activated again? Answers to these kinds of questions will contribute to our overall understanding of how cells grow, divide, and become specialized.

Basic research into these fundamental processes may also lead to the development of new therapies to treat human disease. It is not possible to predict from where the essential new discoveries will come. However, already the birth of Dolly has sparked ideas about potential benefits that might be realized. To explore the possibility of these new therapies, extensive basic research is needed.

Much of this basic research will likely be done in the mouse as this animal is widely used by developmental biologists, and thus a great deal is already known about its development. However, as described above, the use of cloning in other animals—such as cows, pigs and sheep—by agricultural and biotechnology companies will also contribute to understanding of the basic processes involved. The study of nuclear transplantation cloning in a wide variety of animals will be very useful. Although many of the basic cellular mechanisms underlying animal development are the same in all mammals, there are subtle developmental variations that often lead to major technical differences in working with a particular species. Because a technique is often perfected in one species before being applied to another, knowing which parts of the techniques are widely applicable and which might need to be perfected for the given species will be of great value. This body of research into animal systems will answer many questions about the feasibility of various new therapeutic applications being proposed for human cells. New innovations in treating human disease can be tested in animal systems to determine if the basic foundation of the idea is sound before experiments using human cells would be required. Thus the path to testing the potential therapies to treat human disease, described below, should initially go through testing in animal models before progressing to human cell research.

Potential Therapeutic Applications of Nuclear Transfer Cloning

The demonstration that, in mammals as in frogs, the nucleus of a somatic cell can be reprogrammed by the egg environment provides further impetus to studies on how to reactivate embryonic programs of development in adult cells. These studies have exciting prospects for regeneration and repair of diseased or damaged human tissues and organs, and may provide clues as to how to reprogram adult differentiated cells directly without the need for oocyte fusion. In addition, the use of nuclear transfer has potential application in the field of assisted reproduction.

Potential Applications in Organ and Tissue Transplantation

Many human diseases, when they are severe enough, are treated effectively by organ or tissue transplantation, including some leukemias, liver failure, heart and kidney disease. In some instances the organ required is non-vital, that is, it can be taken from the donor without great risk (e.g., bone marrow, blood, kidney). In other cases, the organ is obviously vital and required for the survival of the individual, such as the heart. All transplantation is imperfect, with the exception of that which occurs between identical twins, because transplantation of organs between individuals requires genetic compatibility.

In principle, the application of nuclear transfer cloning to humans could provide a potential source of organs or tissues of a predetermined genetic background. The notion of using human cloning to produce individuals for use solely as organ donors is repugnant, almost unimaginable, and morally unacceptable. A morally more acceptable and potentially feasible approach is to direct differentiation along a specific path to produce specific tissues (e.g., muscle or nerve) for therapeutic transplantation rather than to produce an entire individual. Given current uncertainties about the feasibility of this, however, much research would be needed in animal systems before it would be scientifically sound, and therefore potentially morally acceptable, to go forward with this approach.

Potential Applications in Cell-based Therapies

Another possibility raised by cloning is transplantation of cells or tissues not from an individual donor but from an early embryo or embryonic stem cells; the primitive, undifferentiated cells from the embryo that are still totipotent. This potential application would not require the generation and birth of a cloned individual. Embryonic stem cells provide an interesting model for such studies, since they represent the precursors of all cell lineages in the body. Mouse embryonic stem cells can be stimulated to differentiate *in vitro* into precursors of the blood, neuronal and muscle cell lineages, among others (Weiss and Orkin, 1995), and they thus provide a potential source of stem cells for regeneration of all tissues of the body.

It might be possible to take a cell from an early blastomere and treat it in such a manner as to direct its differentiation along a specific path. By this procedure it might be possible to generate in the laboratory sufficient numbers of specialized cells, for example bone marrow stem cells, liver cells, or pancreatic beta-cells (which produce insulin) for transplantation. If even a single tissue type could be generated from early embryonic cells by these methods and used clinically, it would constitute a major advance in transplantation medicine by providing cells that are genetically identical to the recipient.

One could imagine the prospect of nuclear transfer from a somatic cell to generate an early embryo and from it an embryonic stem cell line for each individual human, which would be ideally tissue-matched for later transplant purposes. This might be a rather expensive and far-fetched

scenario. An alternative scenario would involve the generation of a few, widely used and well characterized human embryonic stem cell lines, genetically altered to prevent graft rejection in all possible recipients.

The preceding scenarios depend on using cells of early human embryos, generated either by *in vitro* fertilization or nuclear transfer into an egg. Because of ethical and moral concerns raised by the use of embryos for research purposes it would be far more desirable to explore the direct use of human cells of adult origin to produce specialized cells or tissues for transplantation into patients. It may not be necessary to reprogram terminally differentiated cells but rather to stimulate proliferation and differentiation of the quiescent stem cells which are known to exist in many adult tissues, including even the nervous system (Gage, et al., 1995). Experiments in this area are likely to focus more on the conditions required for direct stimulation of the stem cells in specific tissues, than actual use of nuclear transfer to activate novel developmental programs. These approaches to cellular repair using adult stem cells will be greatly aided by an understanding of how stem cells are established during embryogenesis.

Another strategy for cell-based therapies would be to identify methods by which somatic cells could be “de-differentiated” and then “re-differentiated” along a particular path. This would eliminate the need to use cells obtained from embryos. Such an approach would permit the growth of specialized cells compatible with a specific individual person for transplantation. Although at the current time this strategy is highly speculative, ongoing research in animal systems may identify new approaches or new molecular targets that might make this approach feasible.

It will be of great importance to understand through experiments in animals how the environment of the egg reprograms a somatic cell nucleus. What cellular mechanisms can be elucidated? What components are involved in these processes? Can we direct cells along particular developmental pathways in the laboratory and use these cells for therapy? The capacity to grow human cells of different lineages in culture would also dramatically improve prospects for effective somatic gene therapy.

Assisted Reproduction

Another area of medicine where the knowledge gained from animal work has potential application is in the area of assisted reproduction. Assisted reproduction technologies are already widely used and encompass a variety of parental and biological situations, that is, donor and recipient relationships. In most cases, an infertile couple seeks remedy through either artificial insemination or *in vitro* fertilization using sperm from either the male or an anonymous donor, an egg from the woman or a donor, and in some cases surrogacy. In those instances where both individuals of a couple are infertile or the prospective father has non-functional sperm, one might envision using cloning of one member of the couple’s nuclei to produce a child.

Although this constitutes an extension of current clinical practice, aside from the serious, moral, and ethical issues surrounding this approach, there are significant technical and medical causes for caution, some of which were described in the research questions enumerated above.

In most situations of assisted reproduction, other than the intentional union of the gametes by *in vitro* techniques, the fertilized egg and initial cells of the early embryo are not otherwise manipulated. In some rare cases, such as preimplantation genetic diagnosis, the embryo is manipulated by the removal of one of the identical cells of the blastomere to test its genetic status. In contrast, if nuclear transfer were to be used as a reproductive option, it would entail substantially more invasive manipulation. Thus far, the animal cloning of Dolly is a singular success, one seemingly normal animal produced from 277 nuclear transfers. Until the experiment is replicated the efficiency, and even the validity, of the procedure cannot be fully determined. It is likely that the mere act of manipulating a nucleus and transferring it into an egg could decrease the percentage of eggs that go on to develop and implant normally, as well as increase the rate of birth defects.

Cloning and Genetic Determinism

The announcement of Dolly sparked widespread speculation about a human child being created using somatic cell nuclear transfer. Much of the perceived fear that greeted this announcement centered around the misperception that a child or many children could be produced who would be identical to an already existing person.

This fear reflects an erroneous belief that a person's genes bear a simple relationship to the physical and psychological traits that compose that individual. This belief, that genes alone determine all aspects of an individual, is called "genetic determinism." Although genes play an essential role in the formation of physical and behavioral characteristics, each individual is, in fact, the result of a complex interaction between his or her genes and the environment within which they develop, beginning at the time of fertilization and continuing throughout life. As social and biological beings we are creatures of our biological, physical, social, political, historical, and psychological environments. Indeed, the great lesson of modern molecular genetics is the profound complexity of both gene-gene interactions and gene-environment interactions in the determination of whether a specific trait or characteristic is expressed. In other words, there will never be another you.

While the concept of complete genetic determinism is wrong and overly simplistic, genes do play a major role in determining biological characteristics including a predisposition to certain diseases. Moreover, the existence of families in which many members are affected by these diseases suggest that there is a single gene that is passed down with each generation that causes the disease. When such a disease gene is identified, scientists often say they have "cloned the gene for" breast cancer, for instance, implying a direct cause and effect of gene and disease. Indeed, the recent efforts of the Human Genome Project have led to the isolation of a large number of genes

that are mutated in specific diseases, such as Duchenne Muscular Dystrophy, and certain types of breast and colon cancer.

However, recent scientific findings have revealed that a “one-gene, one-disease” approach is far too simplistic. Even in the relatively small list of genes currently associated with a specific disease, knowing the complete DNA sequence of the gene does not allow a scientist to predict if a given person will get the disease. For example, in breast cancer there can be many different changes in the DNA, and for some specific mutations there is a calculated risk of developing the disease, while for other changes the risk is unknown. Even when a specific genetic change is identified that “causes” the disease in some people, others may be found who have the same change but do not get the disease. This is because other factors, either genetic or environmental, are altered that mask or compensate for “the” disease gene. Thus even with the most sophisticated understanding of genes, one cannot determine with certainty what will happen to a given person with a single change in a single gene.

Once again, the reason rigid genetic determinism is false is that genes interact with each other and with the environment in extremely complex ways. For example, the likelihood of developing colon cancer, a disease with a strong hereditary component and for which researchers have identified a single “causative” gene, is also strongly influenced by diet. When one considers a human trait that is determined by multiple genes, the situation becomes even more complex. The number of interactions between genes and environment increases dramatically. In fact, the ability to predict what a person will be like knowing only their genes becomes virtually impossible because it is not possible to know how the environment and chance factors will influence the outcome.

Thus the idea that one could make through somatic cell nuclear transfer a team of Michael Jordans, a physics department of Albert Einsteins, or an opera chorus of Pavarottis, is simply false. Knowing the complete genetic makeup of an individual would not tell you what kind of person that individual would become. Even identical twins who grow up together and thus share the same genes and a similar home environment have different likes and dislikes, and can have very different talents. The increasingly sophisticated studies coming out of human genetics research are showing that the better we understand gene function, the less likely it is we will ever be able to produce at will a person with any given complex trait.

Conclusions

The term “clone” has many meanings but in its simplest and most scientific sense it means the making of identical copies of molecules, cells, tissues, and even entire animals. The latest news about cloning Dolly the sheep involved somatic cell nuclear transplant cloning. In this process the nucleus from an adult somatic cell is transplanted into an enucleated ovum to produce a developing animal that is a “delayed” genetic twin of the adult.

There are many applications that nuclear transfer cloning might have for biotechnology, livestock production, and new medical approaches. Work with embryonic stem cells and genetic manipulation of early embryos in animal species (including nuclear transfer) is already providing unparalleled insights into fundamental biological processes and promises to provide great practical benefit in terms of improved livestock, improved means of producing pharmaceutical proteins, and prospects for regeneration and repair of human tissues.

However, the possibility of using human cloning for the purposes of creating a new individual entails significant scientific uncertainty and medical risk at this time. Potential risks include those known to be associated with the manipulation of nuclei and eggs and those yet unknown, such as the effects of aging, somatic mutation, and improper imprinting. These effects could result in high rates of failed attempts at pregnancy as well as the increased likelihood of developmentally and genetically abnormal embryos.

References

- Baron, M.H., and T. Maniatis, "Rapid reprogramming of globin gene expression in transient heterokaryons," *Cell* 46:591-602, 1986.
- Blau, H.M., "Differentiation requires continuous active control," *Annual Review of Biochemistry* 61:1213-1230, 1992.
- Blau, H.M., Pavlath, G.K., Hardeman, E.C., Chiu, C.P., Silberstein, L., Webster, S.G., Miller, S.C., and C. Webster, "Plasticity of the differentiated state," *Science* 230:758-766, 1985.
- Braude, P., Bolton, V., and S. Moore, "Human gene expression first occurs between the four- and eight-cell stages of preimplantation development," *Nature* 332:459-461, 1988.
- Briggs, R., and T.J. King, "Transplantation of living nuclei from blastula cells into enucleated frog's eggs," *Proceedings of the National Academy of Sciences (USA)* 38:455-463, 1952.
- Campbell, K.H., Loi, P., Cappai, P., and I. Wilmut, "Improved development to blastocyst of ovine nuclear transfer embryos reconstructed during the presumptive S-phase of enucleated activated oocytes," *Biology of Reproduction* 50:1385-1393, 1994.
- Campbell, K.H., McWhir, J., Ritchie, W.A., and I. Wilmut, "Sheep cloned by nuclear transfer from a cultured cell line," *Nature* 380:64-66, 1996.
- Capecchi, M. R., "The new mouse genetics: altering the genome by gene targeting," *Trends in Genetics* 5:70-76, 1989.
- Cheong, H.T., Takahashi, Y., and H. Kanagawa, "Birth of mice after transplantation of early cell-cycle-stage embryonic nuclei into enucleated oocytes," *Biology of Reproduction* 48:958-963, 1993.
- Chiu, C.P., and C.B. Harley, "Replicative senescence and cell immortality: The role of telomeres and telomerase," *Proceedings of the Society for Experimental Biology and Medicine* 214:99-106, 1997.
- Collas, P., and F.L. Barnes, "Nuclear transplantation by microinjection of inner cell mass and granulosa cell nuclei," *Molecular Reproduction and Development* 38:264-267, 1994.
- Collas, P., Balise, J. J., and J.M. Robl, "Influence of cell cycle stage of the donor nucleus on development of nuclear transplant rabbit embryos," *Biology of Reproduction* 46:492-500, 1992.

Colman, A., "Production of proteins in the milk of transgenic livestock: Problems, solutions, and successes," *American Journal of Clinical Nutrition* 63:639S-645S, 1996.

Fundele, R.H., and M.A. Surani, "Experimental embryological analysis of genetic imprinting in mouse development," *Developmental Genetics* 15:515-522, 1994.

Fulka, J., First, N.L., and R.M. Moor, "Nuclear transplantation in mammals: remodeling of transplanted nuclei under the influence of maturation promoting factor," *BioEssays* 18:835-840, 1996.

Graham, C.F. "The fusion of cells with one- and two-cell mouse embryos," *Wistar Institute Symposium Monographs* 9:19-35, 1969.

Gage, F.H., Ray, J., and L.J. Fisher, "Isolation, characterization, and use of stem cells from the CNS," *Annual Review of Neuroscience* 18:159-192, 1995.

Gurdon, J.B. "The developmental capacity of nuclei taken from intestinal epithelium cells of feeding tadpoles," *Journal of Embryology and Experimental Morphology* 10, 622-640, 1962.

Gurdon, J.B., Laskey, R.A., and O. R. Reeves, "The developmental capacity of nuclei transplanted from keratinized skin cells of adult frogs," *Journal of Embryology and Experimental Morphology* 34:93-112, 1975.

Houdebine, L.M., "Production of pharmaceutical proteins from transgenic animals," *Journal of Biotechnology* 34:269-287, 1994.

Latham, K.E., Garrels, J.I., and D. Solter, "Alterations in protein synthesis following transplantation of mouse 8- cell stage nuclei to enucleated 1- cell embryos," *Developmental Biology* 163:341-350, 1994.

Mantell, L.L., and C.W. Greider, "Telomerase activity in germline and embryonic cells of *Xenopus*," *EMBO Journal* 13:3211-3217, 1994.

McGrath, J., and D. Solter, "Inability of mouse blastomere nuclei transferred to enucleated zygotes to support development in vitro," *Science* 226:1317-1319, 1984.

Nagy, A., Rossant, J., Nagy, R., Abramow-Newerley, W., and J.C. Roder, "Derivation of completely cell culture-derived mice from early passage embryonic stem cells," *Proceedings of the National Academy of Sciences (USA)* 90:8424-8428, 1993.

Prather, R.S., Sims, M.M., and N.L. First, "Nuclear transplantation in early pig embryos," *Biology of Reproduction* 41:414-418, 1989.

- Prather, R.S., and N.L. First, "Cloning embryos by nuclear transfer," *Journal of Reproduction and Fertility. Supplement* 41:125-134, 1990.
- Pursel, V.G., Pinkert, C.A., Miller, K.F., Bolt, D.J., Campbell, R.G., Palmiter, R.D., Brinster, R.L., and R.E. Hammer, "Genetic engineering of livestock," *Science* 244: 1281-1288, 1989.
- Robertson, E.J., "Pluripotent stem cell lines as a route into the mouse germ line," *Trends in Genetics* 2:9-13, 1986.
- Rossant J., and R.A. Pederson, *Experimental Approaches to Mammalian Embryonic Development* (Cambridge: Cambridge University Press, 1986).
- Schultz, R.M., "Regulation of zygotic gene activation in the mouse," *BioEssays* 15:531-538, 1993.
- Sims, M., and N.L. First, "Production of calves by transfer of nuclei from cultured inner cell mass cells," *Proceedings of the National Academy of Sciences (USA)* 91:6143-6147, 1994.
- Smith, L.C., and I. Wilmut, "Influence of nuclear and cytoplasmic activity on the development in vivo of sheep embryos after nuclear transplantation," *Biology of Reproduction* 40:1027-1035, 1989.
- Solter, D., "Differential imprinting and expression of maternal and paternal genomes," *Annual Review of Genetics* 22:127-146, 1988.
- Stice, S. L., and C.L. Keefer, "Multiple generational bovine embryo cloning," *Biology of Reproduction* 48:715-719, 1993.
- Stice, S.L., Keefer, C.L., and L. Mathews, "Bovine nuclear transfer embryos: Oocyte activation prior to blastomere fusion," *Molecular Reproduction and Development* 38:61-68, 1994.
- Ward, K.A., and C.D. Nancarrow, "The commercial and agricultural applications of animal transgenesis," *Molecular Biotechnology* 4:167-178, 1995.
- Weintraub, H., "The MyoD family and myogenesis: redundancy, networks, and thresholds," *Cell* 75: 1241-1244, 1993.
- Weiss, M.J., and S.H. Orkin, "In vitro differentiation of murine embryonic stem cells: New approaches to old problems," *Journal of Clinical Investigation* 97:591-595, 1995.
- Willadsen, S.M., "Nuclear transplantation in sheep embryos," *Nature* 320:63-65, 1986.

Wilmot, I., Schnieke, A.E., McWhir, J., Kind, A.J., and K.H. Campbell, "Viable offspring derived from fetal and adult mammalian cells," *Nature* 385:810-813, 1997.

Yang X., Jiang, S., Kovacs, A., and R. H. Foote, "Nuclear totipotency of cultured rabbit morulae to support full-term development following nuclear transfer," *Biology of Reproduction* 47:636-643, 1992.

Chapter Three

RELIGIOUS PERSPECTIVES

Over the last twenty-five years religious thinkers have discussed the prospect of human cloning in the context of long-standing religious traditions that often influence and guide citizens' responses to new technologies. Religious positions on human cloning are pluralistic in their premises, modes of argument, and conclusions. Nevertheless, several major themes are prominent in Jewish, Roman Catholic, Protestant, and Islamic positions, including responsible human dominion over nature, human dignity and destiny, procreation, and family life. Some religious thinkers argue that cloning a human to create a child would be intrinsically immoral and thus could never be morally justified; they usually propose a ban on such human cloning. Some other religious thinkers contend that human cloning to create a child could be morally justified under some circumstances but hold that it should be strictly regulated in order to prevent abuses.

* * * * *

Media reports often depict the debate over the prospects of cloning humans as a classical confrontation between science and religion. This depiction is misleading. Not all arguments against cloning humans are religious, and not all religious thinkers oppose the cloning of humans in all circumstances. Furthermore, many contend that the possibility of cloning humans offers an opportunity for substantive dialogue between scientists and theologians. Probing the intersections of ethics, science, and theology can offer mutual enrichment. Scientists can see how research in genetics and biology raises theological questions, while theologians can consider whether and how religious convictions can accommodate new scientific knowledge (Gustafson, 1994). Therefore, the Commission sought to determine the positions on human cloning via somatic cell nuclear transfer held by a variety of religious thinkers and the arguments they offer to support their positions. The Commission was interested in religious arguments and conclusions about human cloning because religious traditions influence and guide many citizens' responses to various issues in biomedicine, including such novel developments as human cloning.

For purposes of recommending public policy in a democratic society, the Commission was also interested in the extent to which moral arguments in various religious traditions rest on premises accessible to others outside those traditions. Sometimes religious thinkers appeal to categories such as "nature," "reason," "basic human values," and "family values" that may speak to citizens outside their traditions because these categories do not necessarily depend solely on particular faith commitments, scripture, revelation, or religious authority. Such categories may therefore contribute to a broader societal discussion of the ethical arguments for and against cloning humans, which are examined further in the following chapter. Indeed, NBAC was interested in determining whether various religious traditions and secular approaches achieve a

rough consensus about appropriate public policy toward creating children through somatic cell nuclear transfer at this time.

Finally, the views of a wide range of communities, including religious communities, are important in determining whether policies under consideration are feasible and whether their social benefits outweigh their social costs. For example, a particular policy may not be feasible, and may even be counterproductive, if it engenders vigorous, widespread, and sustained moral objection.

NBAC solicited oral and written presentations from scholars in several religious traditions, contracted for a scholarly analysis of the views of these and other religious traditions,⁵ and received public testimony and written submissions from various other individuals and groups with religious orientations. What follows builds on these materials and presents some of the key themes in several western religious interpretations and evaluations of cloning humans. This chapter is presented in the spirit of sustaining a national dialogue but also in complete awareness that the Commission may not have fully understood the traditions described. (This chapter concentrates on Jewish, Roman Catholic, Protestant, and Islamic views; a discussion of other religious views appears in the commissioned paper by Courtney Campbell.)

Religion and Human Cloning: An Historical Overview

It is possible to identify four recent overlapping periods in which theologians and other religious thinkers have considered the scientific prospects and ethics of the cloning of humans. The first phase, which began in the mid-1960s and continued into the early 1970s, was shaped by a context of expanded choices and control of reproduction (e.g., the availability of the birth control pill), the prospects of alternative, technologically-assisted reproduction (e.g., *in vitro* fertilization [IVF]), and the advocacy by some biologists and geneticists of cloning “preferred” genotypes, which, in their view, would avoid overloading the human gene pool with genes that are linked to deleterious outcomes and that could place the survival of the human species at risk.

Several prominent theologians engaged in these initial discussions of human genetic manipulation and cloning, including Charles Curran, Bernard Häring, Richard McCormick, and Karl Rahner within Roman Catholicism, and Joseph Fletcher and Paul Ramsey within Protestantism. The diametrically opposed positions staked out by the last two theologians gave an early signal of the wide range of views that are still expressed by religious thinkers.

Joseph Fletcher advocated expansion of human freedom and control over human reproduction. He portrayed the cloning of humans as one of many present and prospective reproductive options that could be ethically justified by societal benefit. Indeed, for Fletcher, as a method of reproduction, cloning was preferable to the “genetic roulette” of sexual reproduction.

⁵ Much of the material in this chapter is derived from a commissioned paper prepared for the National Bioethics Advisory Commission by Courtney S. Campbell, Department of Philosophy, Oregon State University, titled “Religious Perspectives on Human Cloning.”

He viewed laboratory reproduction as “radically human” because it is deliberate, designed, chosen, and willed (Fletcher, 1971; 1972; 1974; 1979).

By contrast, Paul Ramsey portrayed the cloning of humans as a “borderline” or moral boundary that could be crossed only at risk of compromise to humanity and to basic concepts of human procreation. Cloning threatened three “horizontal” (person-person) and two “vertical” (person-God) border crossings. First, clonal reproduction would require directed or managed breeding to serve the scientific ends of a controlled gene pool. Second, it would involve non-therapeutic experimentation on the unborn. Third, it would assault the meaning of parenthood by transforming “procreation” into “reproduction” and by severing the unitive end (expressing and sustaining mutual love) and the procreative end of human sexual expression. Fourth, the cloning of humans would express the sin of pride or hubris. Fifth, it could also be considered a sin of self-creation as humans aspire to become a “man-God” (Ramsey, 1966; 1970).

A second era of theological reflection on cloning humans began in 1978, a year that was notable for two events, the birth in Britain of the first IVF baby, Louise Brown, and the publication of David Rorvik's *In His Image*, an account alleging (falsely) the creation of the first cloned human being (Rorvik, 1978). Christian theologians concentrated more on the ethical issues raised by IVF, while Jewish scholars, such as Seymour Siegel and Fred Rosner, also directed attention to cloning humans, and were neither as supportive as Fletcher nor as critical as Ramsey. They instead indicated the need for more extensive discussion of this topic within the Jewish community.

This period also witnessed the beginning of formal ecclesiastical involvement with questions of genetic manipulation. In 1977 the United Church of Christ produced a study booklet on “Genetic Manipulation,” which appears to be the earliest reference to human cloning among Protestant denominational literature (Lynn, 1977). It provided a general overview of the science and ethics of cloning humans but stopped short of a specific theological verdict.

Protestant-organized ecumenical bodies such as the World Council of Churches (1975, 1982, 1989) and the National Council of Churches of Christ (1980, 1983, 1986), as well as some individual denominations, issued resolutions or position statements that cautiously endorsed genetic interventions for therapeutic purposes. In addition, in 1979, concerns about genetic engineering expressed by Jewish, Protestant, and Roman Catholic leaders led President Jimmy Carter to ask the President’s Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research to examine the scientific, ethical, and social issues of gene splicing (President's Commission, 1982). The President’s Commission addressed the aspects of “genetic engineering” that use recombinant DNA technology to treat disease, but it did not address other procedures often encompassed by the phrase, such as IVF or cloning organisms.

The discussions of the 1970s continued into the 1980s with particular attention to IVF, artificial insemination by donor, and surrogacy. These techniques challenged traditional notions of the family by separating genetic and rearing fatherhood and genetic, gestational, and rearing

motherhood, as well as raising questions about whether the contractual and commercial ties in many of these arrangements were inimical to traditional religious views of the family.

A third era of religious discussion began in 1993 with the report from George Washington University of the separation of cells in human blastomeres to create multiple, genetically identical embryos. The Roman Catholic Church expressed vigorous opposition to the procedure, and a Vatican editorial denounced the research as “intrinsically perverse.” Catholic moral theologians invoked norms of individuality, dignity, and wholeness in condemning this research (McCormick, 1993; 1994; Shannon, 1994). While many Conservative Protestant scholars held that this research contravened basic notions of personhood such as freedom, the sanctity of life, and the image of God, some other Protestant scholars noted its potential medical benefits and advocated careful regulation rather than prohibition.

The fourth and most recent stage of religious discussion has come in the wake of the successful cloning of Dolly the sheep through the somatic cell nuclear transfer technique, as the cloning of a human once again appeared to be a near-term possibility. Several Roman Catholic and Protestant thinkers have reiterated and reinforced past opposition and warnings. For example, Protestant theologian Allen Verhey drew on the arguments initially voiced by Paul Ramsey in concluding that an account of the good life in a family is “inhospitable” to the cloning of humans (Verhey, 1994;1997).

However, some Protestant thinkers, in reflecting on the meaning of human partnership with ongoing divine creative activity, have expressed qualified support for cloning research and for creating children using somatic cell nuclear transfer techniques. Likewise, some Jewish and Islamic thinkers encourage continuing laboratory research on animal models and even laboratory work on the possibility of cloning human beings (only in pursuit of a worthy objective), while expressing deep moral reservations, at least at this time, about the transfer of a human embryo obtained by nuclear transfer techniques to a womb for purposes of gestation and birth. Testimony presented to NBAC in public hearings on March 13 and 14, 1997, provides some of the earliest theological statements in this renewed discussion of the ethics of cloning research and of cloning humans.

Several conclusions emerge from this brief historical overview:

- Over the past twenty-five years, theologians have engaged in repeated discussions of the prospect of cloning humans that anticipate and illuminate much current religious discussion of this topic.
- Theological and ecclesiastical positions on cloning humans are pluralistic in their premises, their modes of argument, and even their conclusions. In short, they exhibit the pluralism characteristic of American religiosity.

- The religious discussion of cloning humans has connected it closely with on-going debates about technologically-assisted reproduction and genetic interventions.
- Despite changes in scientific research and technical capability, the values that underlie religious concerns about cloning humans have endured and continue to inform public debate.

Themes in Theological Bioethics

This section, without any pretense of comprehensiveness, examines several major, overlapping themes in Western faith traditions that bear on positions taken on the cloning of humans. It considers both broad religious convictions and moral norms. These traditions have articulated a variety of ethical norms to address a wide range of practical issues and problems. These norms may be derived from sacred writings, traditions of interpretation, reason, and personal experience, among other sources, and they can be applied to the wide array of moral choices people confront from the beginning to the end of life.

The Biblical Account of the Creation of Humans

The question of personhood or human distinctiveness is commonly described and explained in Judaism and Christianity with reference to the theological theme of creation in the image of God. Interpretations of the moral meaning of the image of God depend on prior convictions about the nature of God and the characteristics of God that human beings are believed to reflect. The biblical story of creation is most commonly used for interpreting the image of God. Particularly significant is the language of Genesis, chapter 1, verses 27-28: “So God created man in his own image, in the image of God he created him, male and female he created them. And God blessed them, and God said to them, ‘Be fruitful and multiply, and fill the earth and subdue it; and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth’” (Revised Standard Version).

Several characteristics of humanity have been inferred and explicated from the biblical story of creation:

- Human beings as created in God’s image receive the gift of freedom and moral agency. Moral agency is inherent in the human self and creates moral responsibilities that include respect for the equal freedom and agency of other persons. The moral correlate of personal freedom is personal responsibility for actions before one’s conscience, others, and ultimately God.
- Humans are fundamentally equal because they are all created in God’s image. Their fundamental equality transcends any differentiation based on gender, race, class, or ethnicity.

- Human beings are also relational and social creatures. They are created in and for relationships with God and for community with other persons as well as the rest of creation.
- The image of God is reflected in human diversity, including, but not limited to, gender diversity. The differentiation of the sexes represents the divine warrant for procreation as well as a positive evaluation of sexuality.
- Human beings are embodied selves. The person is revealed and experienced through the body, not merely as an intellectual or spiritual essence, or as a disembodied mind or will.
- Although human beings are in nature, they also transcend nature, and they express the image of God through the exercise of their creative capacities and potential, including their “dominion” over the natural world.
- Although human beings are created in God's image, they are not God. They are finite and fallible, with limited capacities to predict and direct the course of actions they initiate, or to assess accurately the outcomes of these actions.

Each of these features of the image of God helps explain religious responses to the prospects of creating a child through human cloning. Nevertheless, different religious traditions and strands within those traditions interpret and weight these features and their implications somewhat differently, particularly in relation to the divine commands that follow the creation of humans in God's image. These different views of humans as created in the image of God, with certain responsibilities, are reflected in major religious themes regarding the cloning of humans: responsible human dominion over nature; human dignity; and procreation and families.

Responsible Human Dominion Over Nature

Warnings Not to Play God. As often happens when a powerful new scientific tool is developed, the announcement that mammalian somatic cell nuclear transfer cloning was possible generated strong warnings against “playing God.” This slogan is usually invoked as a moral stop sign to some scientific research or medical practice on the basis of one or more of the following distinctions between human beings and God:

- Human beings should not probe the fundamental secrets or mysteries of life, which belong to God.
- Human beings lack the authority to make certain decisions about the beginning or ending of life. Such decisions are reserved to divine sovereignty.
- Human beings are fallible and also tend to evaluate actions according to their narrow, partial, and frequently self-interested perspectives.

- Human beings do not have the knowledge, especially knowledge of outcomes of actions, attributed to divine omniscience.
- Human beings do not have the power to control the outcomes of actions or processes that is a mark of divine omnipotence.

The warning against “playing God” serves to remind human beings of their finiteness and fallibility. By not recognizing appropriate limits and constraints on scientific aspirations, humans reenact the Promethean assertion of pride or hubris. In the initial theological discussions of cloning humans, Ramsey summarized his objections by asserting: “Men ought not to play God before they learn to be men, and after they have learned to be men, they will not play God” (Ramsey, 1970).

Even within religious communities, however, the warning against “playing God” may not be considered a sufficient argument against human cloning. Allen Verhey contends that this warning is simply too indiscriminate to provide ethical guidance. Furthermore, it overlooks moral invitations to play God, particularly in the realm of genetics (Verhey, 1995). While agreeing with Ramsey that human beings are not called to “play God,” Protestant Ted Peters argues that this does not by itself define what is necessary for us to be human. Hence, we are responsible for using our creativity and freedom (features of the image of God) to forge a destiny more consonant with human dignity. In “playing human,” Peters contends, there is no theological reason to leave human nature unchanged, and no theological principles that the cloning of humans necessarily violates (Peters, 1997).

The Quest for Knowledge. For major strands of Christian, Jewish, and Islamic traditions, the quest for scientific knowledge is not, in general, theologically problematic or threatening. Islamic scholars, for example, emphasize that all scientific discovery is ultimately a revelation of the divinely ordained creation. Scientific knowledge is thereby a symbol or sign of God’s creation (Hathout, 1997). Along these lines, Sheikh Fadlallah, a Shi’ite Muslim jurist, commented that the recent cloning discovery occurred “because God allowed it” (Fadlallah, 1997), and Abdulaziz Sachedina, an Islamic scholar, observed that cloning may be a divinely given opportunity for human moral training and maturation (Sachedina, 1997). Positive general assessments of scientific inquiry also appear in Protestant, Catholic, and Jewish traditions. One ecclesiastical statement in the Calvinist tradition, which views the world as a theater of God’s glory, suggests that “in the sciences, the human does indeed receive glimpses of God’s theater” (Reformed Church in America, 1988).

The prospects for dialogue and agreement between religion and science can dissipate in the context of specific scientific applications. For the religious traditions under consideration, scientific descriptions of the world, however important, do not supply theological interpretations or provide the moral standards for acting in the world. Instead, these traditions insist that two principal questions—who controls technological developments, and what are the ends and

purposes of technology—are ethical rather than scientific or technical. Thus, these traditions generally endorse the scientific quest for knowledge, while at the same time sharply criticizing and even rejecting particular applications of scientific discoveries, just as many thinkers within these traditions do with respect to the prospect of cloning humans to create children. Some religious thinkers also take pains to distinguish their reservations about cloning humans from their response to genetic research in general (Duff, 1997).

Finally, while generally supporting science, many religious thinkers criticize what they perceive to be a “technological imperative,” frequently propelled by commercial forces, to pursue such projects as the cloning of humans when they appear to be possible and/or potentially profitable without giving sufficient attention to the risks involved (Cahill, 1997). Still others insist that, however valuable, scientific “progress” remains an optional goal for the society and its individual members, who should not transgress important moral and human limits in its pursuit (Meilaender, 1997).

Responsible Dominion. Religious traditions variously interpret the biblical mandate of human dominion over nature. Three different interpretations are particularly significant in debates about cloning humans. One common model is an ethic of stewardship, which holds that humans are entrusted with administrative responsibility for creation. Human stewardship involves caring for and cultivating creation after the manner of a gardener. This stewardship ethic, one version of which is prominent in Roman Catholicism, accepts nature as a good to be maintained and preserved.

A second model suggests a “partnership” between human beings and God in caring for and improving upon creation. Rabbi Dorff (1997) notes that “we are God’s ‘partners in the ongoing act of creation’ when we improve the human lot in life.” The Jewish tradition emphasizes that God has given humans a “positive commandment” to “master the world” (Tendler, 1997), and some Jewish thinkers explicate human mastery over nature by reference to the two directions for Adam and Eve in the Garden: They were “to work it [the garden] and to preserve it” (*Genesis* 2:15). To “work” nature is to improve it to meet human needs, and this activity is both right and obligatory “as long as we preserve nature” (Dorff, 1997). It also includes efforts to heal. Human responsibility, in the final analysis, involves “balancing” human and divine actions in this partnership (Dorff, 1997).

This second model also appears in some Islamic thought. One Islamic scholar stresses that “as participants in the act of creating with God, human beings can actively engage in furthering the overall well-being of humanity by intervening in the works of nature, including the early stages of embryonic development, to improve human health” (Sachedina, 1997). The natural world on this second model is inherently malleable and can be shaped in several different ways in service of valuable human and divine goals. Proponents of this model could view cloning research, and perhaps even cloning humans in some circumstances, as using human creative potential for good.

A third perspective, which some Protestants defend, is potentially even more receptive to the prospect of cloning humans. It understands human beings as "created co-creators." On the one hand, human beings are created, dependent on God, and finite and fallible. On the other hand, they assume the role of co-creator to acquire and implement knowledge to improve humanity and the world. Human beings are called to "play human" (Peters, 1997) through their freedom and responsibility in creating an essentially open human future. Reproductive and genetic technologies, along with technologies to create a child through cloning, can express responsible created co-creatorship.

Although Genesis notes that creation is "good" and humanity "very good," humans have displayed, according to some traditions, an irremediable propensity to use their divinely authorized dominion for unauthorized domination, to violate their covenant of partnership with God, and to create after their own image rather than the divine image. The person created in the image of God is thus also marked by a tendency to transgress limits, to commit what some traditions call sin. As a consequence, all human activities are pervasively imperfect. The narratives in Genesis of Adam and Eve in the Garden of Eden, their eating of the fruit of the Tree of the Knowledge of Good and Evil, and the later Tower of Babel often appear in religious discussions of human temptations and tendencies to transgress appropriate limits (see, for example, Tandler, 1997, and Dorff, 1997).

The prospect that humans can and will choose evil rather than good dictates caution as a moral necessity (Gustafson, 1994; Duff, 1997). Even though human imperfection does not necessarily justify halting technological advances, it should, according to many religious thinkers, evoke modesty about human aspirations and achievements (Hefner, 1997).

Human Destiny. Theological views of medicine and medical interventions grounded in themes of creation may be somewhat conservative with respect to reproductive or genetic technologies, not to mention cloning, because of the divine evaluation of nature, including human beings, as good. For instance, the goal of medicine may be conceived as that of restoring disordered biological organisms to their initial goodness, rather than improving them. By contrast, theological positions that focus on human destiny rather than nature can sometimes support an array of reproductive and genetic interventions as ways to improve the human condition.

The question of human destiny has been an underlying theme in the debate about cloning humans from its inception. Several decades ago scientific proponents such as Muller and Lederberg were pessimistic about the survival of the species because of genetic overload. Cloning represented a prospective intervention to avoid this "genetic apocalypse" and promised a future of unlimited possibility. Paul Ramsey's theology of cloning likewise assumed an apocalyptic prognosis of human destiny, though very different in content: "Religious people have never denied, indeed they affirm, that God means to kill us all in the end, and in the end he is going to succeed" (Ramsey, 1970). The end of species survival did not, for Ramsey, justify the means of cloning. Survival is meaningful only if values of human dignity and freedom are respected.

The use of cloning to save the endangered human species is no longer part of the debate, although cloning techniques have received some support to rescue endangered animal species. However, the general question of the extent to which human beings are shapers and creators of their personal and collective futures continues to be important and contested. Some theologians in the debate about cloning humans reject a rigid and static conception of human nature and destiny in favor of a conception that is more open. This more open conception reflects an image of a creative God and a dynamic view of history. The specific theological-ethical interpretation of cloning humans then turns on the nature of human responsibility in the face of uncertain, and perhaps unforeseeable, outcomes.

Some Jewish thinkers affirm that the divine mandate of mastery empowers human beings with the responsibility to shape a malleable world through discovery and innovation. They stress that the Jewish tradition is relatively optimistic because of divine control and care in the face of uncertainty about unanticipated consequences. Indeed, to be overly cautious to the point of moral paralysis may invite trouble. As one Orthodox rabbi has expressed it: “Human beings do the best that they can. If our best cost/benefit analysis says go ahead, we go ahead. ‘G-d protects the simple’ is a Talmudic principle that allows us to assume that when we do our best G-d will take care of what we could not foresee or anticipate. If things do not work out, the theological question is G-d’s to answer; not ours” (Freundel, 1994; 1997). On this view, cloning humans could express moral responsibility insofar as it is directed to the service of God and humanity. Furthermore, some affirm, “children are our destiny” (Dorff, 1997).

Often Jewish thinkers also emphasize the moral education of progeny who will live in the generations to come. One form of immortality discussed in rabbinic sources comes through the influence of parents (and others) on their children. The generations are bound together in part by the ongoing obligations of transmitting knowledge and skills and by teaching and developing moral dispositions. Rabbi Tendler emphasizes the importance of moral education as the best form of human control over cloning technology: “Are we good enough to handle this good technology? Of course we are, if we can set limits on it. And when we can train a generation of children not to murder or steal, we can prepare them not to use this technology to the detriment of mankind” (Tendler, 1997).

Some Protestants emphasize the idea of “continuing creation,” coupled with the theme that persons are co-creators who are called to participate with God in shaping a better future. Indeed, human destiny is so open and indefinite that the Christian may be a “co-explorer” with God in discovering new and unlimited possibilities through innovative technologies (Cole-Turner, 1987). This perspective on human destiny can offer qualified support to human cloning, insofar as it is technically feasible and publicly supported.

These theological accounts of human destiny do not simply bless and anoint scientific progress, because they are balanced, within each tradition, by repeated warnings, often in narrative form, about not crossing certain lines or boundaries. The archetypal figure is Prometheus in Greek mythology, but religious traditions have their own Promethean analogues. The theological caveat

is that creative initiative may be a form of rebellion of the created against the creator. The consequences of such rebellion may include catastrophic havoc and perhaps even destruction of the human creator or of what has been created. This lesson is as fundamental to religious narrative as it is to modern science fiction. The task for religious traditions is to identify what lines may not be crossed and to determine whether cloning a human to create a child is one such line. Much of the debate about limits focuses on human dignity and several related concepts.

Human Dignity

It has been argued that the most significant issue genetic science forces on society concerns the understanding of human nature (Gustafson, 1992). This same issue emerges in theological discourse on the cloning of humans. Lutheran theologian Philip Hefner argues that cloning is a “revelation of the human situation. . . In cloning, we are, in fact, addressing ourselves, and it is about ourselves that we have the greatest questions” (Hefner, 1997). One major theme in the theological conception of creation in God’s image is human dignity: Humans have dignity because they are created in God’s image.

Appeals to human dignity are prominent in Roman Catholic analyses and assessments of the prospects of human cloning, which base “human dignity” on the creation story and on the Christian account of God’s redemption of human beings. The Catholic moral tradition views the cloning of a human being as “a violation of human dignity” (Haas, 1997; see also Moraczewski, 1997). Concerns about human dignity also appear in religious perspectives that are more receptive to the possibility of human cloning; these concerns emerge in the moral limits or conditions they set for human cloning. Even when the language of human dignity is not used, arguments for and specifications of the rights of persons created through cloning often represent what others include under the phrase “human dignity.” And when the language of human dignity is used, it is often specified in more concrete concepts and norms, such as human equality and the sanctity of life.

Religious thinkers generally do not question whether a person created through cloning is a human being created in God’s image. They extend to persons created through cloning the same moral protections that already apply to other persons created in the image of God. For instance, Rabbi Elliot Dorff argues that “[n]o clone may . . . legitimately be denied any of the rights and protections extended to any other child” (Dorff, 1997). However, many fear that the human dignity of persons created through cloning will be violated by the denial of such rights and protections, for instance, through enslavement to others and other forms of “man’s mastery over man” (Tendler, 1997).

Human cloning would violate human dignity, according to some religious opponents, because it would “jeopardize the personal and unique identity of the clone (or clones) as well as the person whose genome was thus duplicated” (Moraczewski, 1997). This problem does not arise in the case of identical twins, because neither is the “source or maker of the other” (Moraczewski, 1997). Religious concerns about identity and individuality focus mainly on how persons created through cloning will inevitably or possibly be treated, rather than whether such

persons are actually unique creatures in God's image. Rejecting genetic determinism, religious thinkers hold that cloning humans would "produce independent human beings with histories and influences all their own and with their own free will" (Dorff, 1997). The person created through cloning will be "a new person, an integrated body and mind, with unique experiences." However, it will doubtless be harder for such persons "to establish their own identity and for their creators to acknowledge and respect it" (Dorff, 1997). Even for absolute opponents, the process of cloning humans only violates human dignity; it does not diminish human dignity: "In the cloning of humans there is an affront to human dignity. . . . Yet, in no way is the human dignity of that person [the one who results from cloning] diminished" (Moraczewski, 1997).

Sanctity of life is one norm associated with human dignity. For instance, the prohibition of the shedding of human blood is connected with God's creation of humans in his own image (Genesis 9:6). Opponents often view the cloning of a human as a breach, or at least as a potential breach, of the sanctity of life. In rejecting human cloning, Joseph Cardinal Ratzinger of the Vatican insisted that "the sanctity of [human] life is untouchable" (quoted in Moraczewski, 1997). Even those who offer limited support for human cloning, in part on the grounds that it could be used in support of life, argue that it is necessary to set conditions and limits in order to prevent harm to persons who are created through cloning. Not only do they rule out such egregious violations of the sanctity of life as sacrificing persons created through cloning in order to obtain their organs for transplantation, they also worry about what will be done with the "bad results," that is, the "mistakes" that will be inevitable at least in the short term (Dorff, 1997). In addition, most recognize that the risks to persons created through cloning are now so unknown that we should virtually rule out human cloning for the present, because those who create children in this manner could not be sure that they are "doing no evil" (Tendler, 1997).

Objectification also represents a fundamental breach of human dignity. To treat persons who are the sources of genetic material for cloning or persons who are created through cloning as mere objects, means or instruments violates the religious principle of human dignity as well as the secular principle of respect for persons. Cloning humans would necessarily involve objectification, some religious thinkers argue, because it would treat the child as "an object of manipulation" by potentially eliminating the marital act and by attempting "to design and control the very identity of the child" (Moraczewski, 1997). Cloning humans is wrong, in short, because "it subjects human individuals at their most vulnerable, at their very coming-into-being, to the arbitrary whim, power and manipulation of others" (Haas, 1997). For other religious thinkers who accept human cloning under some circumstances, it is necessary to reduce the effects of objectification, for example, by a commitment to accept and care for the "mistakes" made in cloning (Dorff, 1997).

Objectification can become commodification when commercial and economic forces determine whether and how a person is treated as an object. Religious opponents of human cloning stress that objectification through commodification is a major risk and worry that "economic incentives will control when humans will be cloned" (Cahill, 1997). Commodification would deny "the sacred character of human life depicted in the Jewish tradition, transforming it

instead to fungible commodities on the human marketplace to be judged by a given person's worth to others" (Dorff, 1997).

Religious thinkers note that the process of human cloning would or could violate the human dignity of agents, that is, those who create children through cloning, as well as the children who are so created. The concepts and norms associated with human dignity cannot be reduced to secular ideas of autonomy, even though they may overlap to some extent. Human dignity sets more limits than autonomy does on what the agent may do. Even though Protestants are often pictured as "stout defenders of human freedom," as one Protestant theologian notes, "they have not located the dignity of human beings in a self-modifying freedom that knows no limit. . ." (Meilaender, 1997). Likewise, a Roman Catholic statement insists that "there is an affront to human dignity for the ones who actively participate in the process as well as for the one who results from the cloning" (Moraczewski, 1997).

Whether creating a human being through cloning necessarily or only under certain circumstances violates human dignity depends on the conception of rights and duties that specify human dignity. For instance, some religious thinkers argue that human cloning would violate inherent human dignity "by exceeding the limits of delegated dominion," a topic that was discussed above (Moraczewski, 1997; see also Haas, 1997). The next section on Procreation and Families will explicate the claim, strongly associated with human dignity in Roman Catholic thought (as well as in some Protestant thought), that those coming into being have a fundamental "right to be engendered by the personal act of a man and a woman committed to one another and their future children in marriage" and not to be subjected to "impersonal manipulative actions which render them susceptible to being used, and thereby abused, by those manipulating them into being" (Haas, 1997).

Procreation and Families

Procreation and Reproduction. In the initial phase of theological debate about cloning humans, Paul Ramsey argued that the covenant of marriage includes the goods of sexual love and procreation, which are divinely ordained and intrinsically related: Human beings have no authority to sever what God had joined together. On this basis, Ramsey, a Protestant, joined with several Roman Catholic moral theologians, such as Bernard Häring and Richard McCormick, in objecting to the cloning of humans as part of the panoply of reproductive technologies. They claimed that such technologies separate the unitive and procreative ends of human sexuality and transform "procreation," which at most puts humans in a role of co-creator, into "reproduction." The Vatican's 1987 Instruction on Respect for Human Life (Donum Vitae) rejected human cloning either as a scientific outcome or technical proposal: "Attempts or hypotheses for obtaining a human being without any connection with sexuality through 'twin fission,' cloning, or parthenogenesis are to be considered contrary to the moral law, since they are in opposition to the dignity both of human procreation and of the conjugal union" (Congregation for the Doctrine of the Faith, 1987).

A similar critique distinguishes “begetting” (procreating) from “making” (reproducing). According to the Nicene Creed of early Christianity, Jesus, as the authentic image of God and the normative exemplar of personhood, is “begotten, not made” of God. The theological interpretation of “begetting” emphasizes likeness, identity, equality; begetting expresses the parent's very being. By contrast, “making” refers to unlikeness, alienation, and subordination; it expresses the parent's will as a project.

Drawing out the implications of this distinction, Oliver O'Donovan, an Anglican theologian, portrays the cloning of humans as the culmination of scientific or technical “making” in human reproduction: “[T]he development of cloning techniques. . . will be a demonstration, if it occurs, that mankind does have the awesome technical power to exchange the humanity which God has given him for something else, to treat natural humanity itself as a raw material for constructing a form of life that is not natural humanity but is an artificial development out of humanity” (O'Donovan, 1984; see also Meilaender, 1997). Thus, this exercise of technological power would come at the cost of an artificial, diminished humanity. It would also disrupt the fundamental relational ties of likeness, identity, and equality. A child created through cloning is designed and manufactured as a product, rather than welcomed as a gift (Meilaender, 1997). Moreover, the process is itself inauthentic, or “fabricated,” with respect to what it means to be human (Ramsey, 1970).

For some religious thinkers, this sharp distinction between begetting and making also challenges widely accepted reproductive technologies. For instance, Lutheran Gilbert Meilaender testified before NBAC that even though human cloning “marks a new and decisive turn,” he “would have gotten off the train” of reproductive technology long before it reached cloning (Meilaender, 1997).

However, many religious thinkers do not accept the sharp separation between begetting and making, because it could rule out various reproductive technologies that they find acceptable, just as many do not accept the absolute connection between unitive and procreative meanings of sexual acts, in part because it would rule out artificial contraception, which they find acceptable. They may, nevertheless, still reject the cloning of humans to create children because they perceive it to be radically different from all other methods of technologically-assisted reproduction. Thus, they may stress the radically new features of human cloning, perhaps even viewing it as a “genuine revolution” in reproduction.

Concerns about the Family. Religious traditions usually approach the cloning of humans to create children from the standpoint of familial relationships and responsibilities rather than from the standpoint of personal rights and individual autonomy. Hence, a primary moral criterion is the impact of cloning humans on the integrity of the family, a concern that includes but also goes beyond the inseparable goods of marriage and the primacy of begetting over making.

The family has been valued as the prime social institution and, in some religious traditions, a divinely ordained institution for the bearing and nurturing of children. Within Roman Catholic

moral teaching, procreation and education of offspring are requirements of natural law. Paul Ramsey's opposition to the cloning of humans stemmed in part from a view that Christians perform their primary responsibility to future generations through procreation and care for children. Jewish law and Islamic law also impose fundamental duties and responsibilities through spousal, parenting, and familial relationships, and through intergenerational ties.

Protestant theologian Allen Verhey appeals to the concept of a “good life in a family” to reject human cloning. He maintains that the primary justifications for human cloning—the principle of freedom and the principle of utility—are necessary but insufficient guidelines for the moral life of a family. In particular, Verhey focuses his critique on the potential disruption of the parent-child relationship: The cloning of humans risks transforming children into “products” of technological achievement rather than “gifts” created in love (Verhey, 1997). As products, children become objects, and objectification violates what it means to treat a child as a gift.

Similarly, Lisa Cahill, a Roman Catholic moral theologian, argues that “the child who is truly the child of a single parent is a genuine revolution in human history, and his or her advent should be viewed with immense caution.” She further contends that cloning violates “the essential reality of human family and ... the nature of the socially related individual within it. We all take part of our identity, both material or biological and social, from combined ancestral kinship networks. The existing practice of ‘donating’ gametes when the donors have no intention to parent the resulting child is already an affront to this order of things. But, in such cases, as in cases of adoption where the rearing of a child within its original combined-family network is impossible or undesirable, the child can still in fact claim the dual-lineage origin that characterizes every other human being. Whether socially recognized or not, this kind of ancestry is an important part of the human sense of self (as witnessed by searches for ‘biological’ parents and families), as well as a foundation of important human relationships.” Cloning humans to create children, Cahill concludes, would constitute an “unprecedented rupture in those biological dimensions of embodied humanity which have been most important for social cooperation” (Cahill, 1997). At the extreme, cloning humans would not only free human reproduction from marital and male-female relationships, but would “allow for the emancipation of human reproduction from any relationship” (Mohler, 1997). Furthermore, echoing Cahill’s concern about “intergenerational family networks,” Protestant theologian Meilaender stresses that the cloning of humans “would symbolically represent an enormous shift in our understanding of the

relation of the generations,” and that this symbolic shift would have incalculably risky effects that should not be unleashed (Meilaender, 1997).

Concerns about lineage and intergenerational relations in other religious traditions also set limits on or challenge the cloning of humans to create children. For example, Islamic scholar Abdulaziz Sachedina suggests that Islam could accept some therapeutic uses of human cloning “as long as the lineage of the child remains religiously unblemished” (Sachedina, 1997, pp. 6-7). And some Jewish thinkers worry that cloning humans may diminish the ethic of responsibility because of changed roles (father, mother, child) and relationships (spousal, parental, filial). It may be unclear who has what responsibilities to whom between and among the generations. According to Rabbi Tendler, “we do not live well with generational inversion” of the sort that human cloning could produce (Tendler, 1997). In particular, he stresses concerns about honoring parents and inheritance laws. However, cloning humans, for acceptable ends, may in some narrow respects be morally “easier” for the Jewish tradition, from the standpoint of its potential impact on the family, than reproductive technologies that use donor insemination or egg donation because it would not raise the same concerns about consanguineous relationships (Dorff, 1997; Tendler, 1997).

Even though concerns about family relationships dominate much of the religious discussion of human cloning, some religious thinkers challenge these concerns. For example, while giving “top priority” to children’s interests in a religious-moral assessment of human cloning, and while noting “serious reasons” for reservations about research into human cloning, Protestant ethicist Nancy Duff argues that “the idea that it would undermine the relationships between men and women or the basic family unit is not . . . morally or theologically convincing” (Duff, 1977, p. 11).

Assessments of Acts and Public Policies

Religious thinkers and traditions often provide moral guidance to participants in their own communities. As a result, they direct many of the themes, norms, and arguments presented in this chapter primarily to those within particular faith traditions. However, religious thinkers and communities also frequently address the larger society, sometimes even proposing specific public policies in addition to trying to alter cultural beliefs, values, and norms. They often base their proposals for public policy on appeals to the “common good” or “public welfare” or “public interest” (for example, Cahill, 1997; Haas, 1997; Duff, 1997; Dorff, 1997; Sachedina, 1997).

Religious perspectives on public policies regarding human cloning vary for several reasons. One critical factor is whether the tradition views every possible act of cloning humans as intrinsically evil (as, for example, Roman Catholicism does) or whether it recognizes that cloning humans could conceivably be justified in some circumstances, however few they may be (as, for example, many in the Jewish tradition do). The Roman Catholic tradition argues that the very use of cloning techniques to create human beings is contrary to human dignity: “One may not use, even for a single instance, a means for achieving a good purpose which intrinsically is morally flawed” (Moraczewski, 1997). And, for that tradition, creating a child through human cloning is

intrinsically morally flawed. Some thinkers in other traditions also hold that such an action is always morally wrong, whatever good might come from it (see Meilaender, 1997).

By contrast, some other religious thinkers believe that cloning a human to create a child could be religiously and morally acceptable under certain conditions. They may view the technology as “morally neutral” (Dorff, 1997) and then consider which uses are morally justified; or they may oppose human cloning from matured (differentiated) cells except in the most exceptional circumstances and then identify those exceptional circumstances.

Two hypothetical scenarios are quite common. The first one involves cloning a sterile person to create a child. Rabbi Tendler poses the case of “a young man who is sterile, whose family was wiped out in the Holocaust, and [who] is the last of a genetic line.” Rabbi Tendler says “I would certainly clone him” (Tendler, 1997). The debate about this type of case hinges in part on different views of infertility. The Jewish tradition often views infertility as an “illness” and thus brings it under the responsibility to heal. According to others, for example, some in the Protestant tradition, the problem of infertility is not serious enough to warrant research into or actual human cloning (Duff, 1997).

A second case involves cloning a person who has a serious and perhaps fatal disease and needs a compatible source of biological material, such as bone marrow. Rabbi Dorff, for instance, holds that it would be “legitimate from a moral and a Jewish point of view” to clone a person with leukemia with the intent of transplanting bone marrow from the created child as long as the “parents” intend to raise the child as they would raise any other child (Dorff, 1997; Tendler, 1997). Some Protestants concur on this case, even when they reject the first type of case (Duff, 1997). Those who consider the second type of case justifiable rule out destruction or abandonment of the created child, as well as the imposition of serious risks of harm. Indeed, acceptance of either type of hypothetical case—as well as a third type of case involving the cloning of a dying child—presupposes that the procedure is safe for the child created by cloning. Other conditions include the protection of the created child’s rights and the lack of acceptable alternatives to cloning persons in such cases.

Those who view cloning humans as intrinsically wrong may also respond sympathetically and compassionately to people’s suffering when they are infertile or have a disease that brings death or disability. However, they usually hold that the good of overcoming this suffering does not justify cloning humans: Cloning “is entirely unsuitable for human procreation even for exceptional circumstances” (Moraczewski, 1997). Indeed, religious critics may view the exceptional circumstances featured in the cases as “temptations” to be resisted (Meilaender, 1997).

Some rough correlations hold between evaluations of particular cases and proposals for public policy. Religious thinkers who view the cloning of a human being as intrinsically wrong,

i.e., wrong in and of itself, under any and all circumstances, tend to support a permanent ban on cloning humans through legislative and other means. Any use of cloning technology to create a human child abuses that technology, which is, however, acceptable in animal reproduction. By contrast, religious thinkers who hold that, in some conceivable circumstances, it could be morally justifiable to clone a person to create a child tend to support public policies that regulate the procedure, with varying restrictions, or that ban the procedure for the time being or until certain conditions are met. In assessing public policies, this second group is particularly concerned to prevent potential abuses of the technology in cloning humans rather than condemning all uses. For instance, they may hold that the government should impose some regulations on cloning “to prevent the most egregious abuses” (Dorff, 1997). Some “egregious abuses,” such as creating people for organ transplants and then discarding their remains, would already be prohibited by criminal law, but new laws and policies may be needed to prevent others.

Most religious thinkers who recommend public policies on cloning humans propose either a ban or restrictive regulation. A few examples will suffice. On March 6, 1997, the Christian Life Commission of the Southern Baptist Convention issued a resolution entitled “Against Human Cloning,” which supported President Clinton’s decision to prohibit federal funding for human-cloning research and requested “that the Congress of the United States make human cloning unlawful.” The resolution also called on “all nations of the world to make efforts to prevent the cloning of any human being.”

The Vatican’s 1987 Instruction on Respect for Human Life (Donum Vitae) argued for a legal prohibition of human cloning, as well as many other reproductive technologies. Official Roman Catholic statements since that time have condemned non-therapeutic research on human embryos and human cloning and have called on governments around the world to enact prohibitive legislation. Most recently, in the wake of the cloning of “Dolly,” a Vatican statement reiterated the basic teaching of Donum Vitae: “A person has the right to be born in a human way. It is to be strongly hoped that states ... will immediately pass a law that bans the application of cloning of humans and that in the face of pressures, they have the force to make no concessions” (“Vatican Calls for Ban,” 1997).

By contrast, Rabbi Elliot Dorff argues that “human cloning should be regulated, not banned.” He holds that “the Jewish demand that we do our best to provide healing makes it important that we take advantage of the promise of cloning to aid us in finding cures for a variety of diseases and in overcoming infertility.” However, “the dangers of cloning . . . require that it be supervised and restricted.” More specifically, “cloning should be allowed only for medical research or therapy; the full and equal status of clones with other fetuses or human beings must be recognized, with the equivalent protections guarded; and careful policies must be devised to determine how cloning mistakes will be identified and handled” (Dorff, 1997). Although Dorff stresses legislation, particularly to regulate privately funded research, he recognizes that legislation will be only partially effective, and for that reason calls for increased attention to hospital ethics committees and institutional review boards, in part because of the self-regulation involved. Hence, although legislation is important “to ban the most egregious practices,” most supervision “should

come from self-regulation akin to what we already have in place for experiments on human subjects”(Dorff, 1997). Many religious thinkers also stress public and professional education.

Several factors other than moral judgments about the moral acceptability or unacceptability of particular cases enter into proposals for public policy. They include, along with the various religious-moral arguments—for example, about the family—already examined in this chapter, the history of eugenics, particularly the Nazi experience; fear of “man’s mastery over man” (Tendler, 1997); the risk of social discrimination and coercion; and the risks of psychological harm to the child created by cloning a human. The most fundamental concern, which is addressed more fully in the Chapter Four, focuses on unknown physical risks to the child (see, for example, Tendler, 1997). Many supporters of a ban or regulation also want to ensure that it will be narrowly and tightly drawn in order to permit necessary and potentially beneficial research.

One important background policy issue for some religious thinkers concerns justice, fairness, or equity in the allocation of resources. Public decisions about funding research, such as research on cloning humans, involve more than assessments of safety and the broad ethical questions that have already been raised in this chapter and will be examined more fully in the next chapter. They also involve setting priorities in the allocation of funds (Sachedina, 1997). Hence, one Protestant theological ethicist argues that society should not proceed with research into cloning humans until it considers the larger questions of allocation, including the “responsible use of limited resources” (Duff, 1997). One standard of evaluation that focuses on the common good targets (a) the most serious problems of disease and disability, and (b) the welfare of society’s most vulnerable members (Duff, 1997).

Conclusions

The wide variety of religious traditions and beliefs epitomizes the pluralism of American culture. Moreover, religious perspectives on cloning humans differ in fundamental premises, modes of reasoning, and conclusions. As a result, there is no single “religious” view on cloning humans, any more than for most moral issues in biomedicine. Nevertheless, discourse on many contested issues in biomedicine still proceeds across religious traditions, as well as secular traditions. Specifically with regard to cloning humans to create children, some religious thinkers believe that this technology could have some legitimate uses and thus could be justified under some circumstances if perfected; however, they may argue for regulation because of the danger of abuses or even for a ban, perhaps temporary, in light of concerns about safety. Other religious thinkers deny that this technology has any legitimate uses, contending that it always violates fundamental moral norms, such as human dignity. Such thinkers often argue for a legislative ban on all cloning of humans to create children. Finally, religious communities and thinkers draw on ancient and diverse traditions of moral reflection to address the cloning of humans, a subject they have debated off and on over the last thirty years. For some, fundamental religious beliefs and norms provide a clear negative answer: It is now and will continue to be wrong to clone a human. Others, however, hold that more reflection is needed, given new scientific and technological

developments, to determine exactly how to interpret and evaluate the prospect of human cloning in light of fundamental religious convictions and norms.

References

- Cahill, L.S., "Cloning: Religion-Based Perspectives," Testimony before the National Bioethics Advisory Commission, March 13, 1997.
- Cole-Turner, R., *The New Genesis: Theology and the Genetic Revolution* (Louisville, KY: Westminster/John Knox Press, 1993).
- Congregation for the Doctrine of the Faith, *Instruction on Respect for Human life in its Origin and on the Dignity of Procreation*, (1987).
- Dorff, R.E.N., "Human Cloning: A Jewish Perspective," Testimony before the National Bioethics Commission, March 14, 1997.
- Duff, N.J., "Theological Reflections on Human Cloning," Testimony presented to the National Bioethics Advisory Commission, March 13, 1997.
- Fadlallah, S.M.H., as cited in "Cloning should be punishable by death or amputation: Saudi cleric," *Agence France Presse*, March 13, 1997.
- Fletcher, J., *Humanhood: Essays in Biomedical Ethics* (Buffalo, NY: Prometheus Books, 1979).
- Fletcher, J., *The Ethics of Genetic Control* (Garden City, NY, Anchor Press, 1974).
- Fletcher, J., "New beginnings in human life: A theologian's response," *The New Genetics and the Future of Man*, M. Hamilton (ed.) (Grand Rapids, MI: Wm. B. Eerdmans Publishing Company, 1972, 78-79).
- Fletcher, J., "Ethical aspects of genetics controls," *New England Journal of Medicine* 285(14):776-783, 1971.
- Freundel, R.B., "Judaism," *On the New Frontiers of Genetics and Religion*, J. Robert Nelson (ed.) (Grand Rapids, MI: Wm. B. Eerdmans Publishing Company, 1994).
- Gustafson, J., "Where theologians and geneticists meet," *Dialog* 33(1):7-16, Winter 1994.
- Haas, J.M., letter from the Pope John Center, submitted to the National Bioethics Advisory Commission, March 31, 1997.
- Hathout, M., "Cloning: Who will set the limits," *The Minaret* 19(3):8, March 1997.

- Hefner, P., "Cloning as quintessential human act," *Insights*, June 1997. (Forthcoming)
- Lynn, B., "Genetic Manipulation," (New York: Office for Church in Society, United Church of Christ, 1977).
- McCormick, R.A., "Blastomere separation: Some concerns," *Hastings Center Report* 24(2):14-16, 1994.
- McCormick, R.A., "Should we clone humans?," *The Christian Century* 17-24:1148-1149, November 1993.
- Meilander, G.C., Testimony before the National Bioethics Advisory Commission, March 13, 1997.
- Moraczewski, Albert S., O.P., "Cloning and the Church," Testimony of the Pope John Center before the National Bioethics Advisory Commission, March 13, 1997.
- Mohler, R.A., "The Brave New World of Cloning: A Christian Worldview Perspective," (unpublished manuscript, March 1997).
- National Council of Churches in Christ, *Genetic Science for Human Benefit* (New York: National Council of Churches, 1986).
- National Council of Churches in Christ, *Genetic Engineering: Social and Ethical Consequences* (New York: National Council of Churches, 1983).
- National Council of Churches in Christ, *Human Life and the New Genetics* (New York: National Council of Churches, 1980).
- O'Donovan, O., *Begotten or Made?* (Oxford: Clarendon Press, 1984).
- Peters, T., *Playing God? Genetic Discrimination and Human Freedom* (New York: Routledge, 1997).
- President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, *Splicing Life* (Washington, DC: U.S. Government Printing Office, 1982).
- Ramsey, P., "Moral and Religious Implications of Genetic Control," *Genetics and the Future of Man*, John D. Roslansky (ed.) (New York: Appleton-Century-Crofts, 1966).
- Ramsey, P., *Fabricated Man: The Ethics of Genetic Control* (New Haven: Yale University Press, 1970).

Reformed Church in America, "Genetic Engineering," *Minutes of General Synod* (New York: Office of Social Witness and Worship, 1988).

Rorvik, D., *In His Image: The Cloning of A Man* (Philadelphia: J.B. Lippincott Company, 1978).

Sachedina, A., "Islamic Perspectives on Cloning," Testimony before the National Bioethics Advisory Commission, March 14, 1997.

Shannon, T.A., Testimony before Senate Hearing on Human Cloning, Commonwealth of Massachusetts, March 10, 1997.

Tendler, R.M., Testimony before the National Bioethics Advisory Commission, March 14, 1997.

Verhey, A., "Cloning: Revisiting an old debate," *Kennedy Institute of Ethics Journal* 4(3):227-234, September 1994.

Verhey, A., "Playing God and invoking a perspective," *Journal of Medicine and Philosophy* 20:347-364, 1995.

World Council of Churches, *Biotechnology: Challenge to the Churches*, Geneva (World Council of Churches, 1989).

World Council of Churches, *Manipulating Life: Ethical Issues in Genetic Engineering* (Geneva, World Council of Churches, 1982).

Chapter Four

ETHICAL CONSIDERATIONS

The prospect of creating children through somatic cell nuclear transfer has elicited widespread concern, much of it in the form of fears about harms to the children who may be born as a result. There are concerns about possible physical harms from the manipulations of ova, nuclei, and embryos which are parts of the technology, and also about possible psychological harms, such as a diminished sense of individuality and personal autonomy. There are ethical concerns as well about a degradation of the quality of parenting and family life if parents are tempted to seek excessive control over their children's characteristics, to value children according to how well they meet overly detailed parental expectations, and to undermine the acceptance and openness that typify loving families. Virtually all people agree that the current risks of physical harm to children associated with somatic cell nuclear transplantation cloning might justify a prohibition at this time on such experimentation. In addition to concerns about specific harms to children, people have frequently expressed fears that a widespread practice of such cloning would undermine important social values, such as opening the door to a form of eugenics or by tempting some to manipulate others as if they were objects instead of persons, and exceeding the moral boundaries inherent in the human condition. Arrayed against these concerns are other important social values, such as protecting personal choice, maintaining privacy and the freedom of scientific inquiry, and encouraging the possible development of new biomedical breakthroughs. As somatic cell nuclear transfer cloning could represent a means of human reproduction for some people, limitations on that choice must be made only when the societal benefits of prohibition clearly outweigh the value of maintaining the private nature of such highly personal decisions. Especially in light of some arguably compelling cases for attempting to create a child through somatic cell nuclear transfer, the ethics of policy making must strike a balance between the values we, as a society, wish to reflect and the freedom of individual choice and any liberties we propose to limit.

* * * * *

One of the key challenges for the Commission has been to understand many of the moral and religious objections to creating human beings using somatic cell nuclear transfer as well as to investigate and articulate the widespread intuitive disapproval of cloning human beings in this manner.¹ This challenge included an initial attempt to examine the plausibility and persuasiveness of these objections and of the counter arguments or especially compelling and specific cases for deploying this technology. As with the concerns offered in opposition to cloning, those offered in its defense also must be examined for their plausibility and persuasiveness. Religious perspectives

¹In support of its analysis, NBAC commissioned a paper written by Dan Brock, Brown University, titled "Cloning Human Beings: An Assessment of the Ethical Issues Pro and Con." Some of the material in this chapter is derived from that paper.

were presented in the previous chapter. This chapter focuses on ethical principles not tied to any particular religious tradition, although these broad principles may be incorporated in the teachings of many religions.

The task is made quite difficult by the fact that neither moral philosophers nor religious thinkers can agree on the "best" moral theory; indeed, they often cannot even agree on the practical implications of any single theory. For example, some people base their arguments on an assessment of the particular harms and benefits that would flow to individuals and to society if somatic cell nuclear transfer techniques were to become commonplace. Others express their views by arguing about overarching rights—the child's right to individuality and dignity versus the nucleus donor's right to procreate or the scientist's right to do research. And while moral and even human rights are not necessarily understood as absolute, a choice to violate such rights requires more than a simple balancing of benefits over harms.

While some of the risks and benefits of somatic cell nuclear cloning of human beings are well enough understood to support the conclusion that it should not be permitted at this time, the difficult task of striking the balance among competing rights and interests needs more time for discussion and development. This chapter reviews some of these arguments which may serve as the starting point for a profound and sustained reflection on the significance of creating children through somatic cell nuclear transfer.

The following discussion of issues raised by such cloning begins with an important caveat. Any research or clinical experiment on creating a child in this manner would involve the creation of an embryo. That is, the fusion of a human somatic cell and an egg whose nucleus has been removed would produce a human embryo, with the apparent potential to be implanted *in utero* and developed to term. Ethical concerns surrounding the issues of embryo research, absent the implantation and carrying to term of an embryo, have recently received extensive analysis and deliberation in our country (National Institutes of Health, 1994). Indeed, as described in Chapter Five, federal funding for human embryo research is severely restricted, although there are few restrictions on human embryo research carried out in the private sector using non-federal funds.

The unique prospect, vividly raised by Dolly, is the creation of a new individual genetically identical to an existing (or previously existing) person—a "delayed" genetic twin. This prospect has been the source of the overwhelming public concern about such cloning. While the creation of embryos for research purposes alone always raises serious ethical questions, the use of somatic cell nuclear transfer to create embryos raises no new issues in this respect. The unique and distinctive ethical issues raised by the use of somatic cell nuclear transfer to create children relate to, for example, serious safety concerns, individuality, family integrity, and treating children as objects. Consequently, the Commission focused its attention on the use of such techniques for the purpose of creating an embryo which would then be implanted in a woman's uterus and brought to term. It also expanded its analysis of this particular issue to encompass activities in both the public and private sector.

Potential for Physical Harms

There is one basis of opposition to somatic cell nuclear transfer cloning on which almost everyone can agree. For reasons outlined in Chapter Two, there is virtually universal concern regarding the current safety of attempting to use this technique in human beings. Even if there were a compelling case in favor of creating a child in this manner, it would have to yield to one fundamental principle of both medical ethics and political philosophy—the injunction, as it is stated in the Hippocratic canon, to “first do no harm.” In addition, the avoidance of physical and psychological harm was established as a standard for research in the Nuremberg Code, 1946-49. At this time, the significant risks to the fetus and physical well being of a child created by somatic cell nuclear transplantation cloning outweigh arguably beneficial uses of the technique.

It is important to recognize that the technique that produced Dolly the sheep was successful in only 1 of 277 attempts. If attempted in humans, it would pose the risk of hormonal manipulation in the egg donor; multiple miscarriages in the birth mother; and possibly severe developmental abnormalities in any resulting child. Clearly the burden of proof to justify such an experimental and potentially dangerous technique falls on those who would carry out the experiment. Standard practice in biomedical science and clinical care would never allow the use of a medical drug or device on a human being on the basis of such a preliminary study and without much additional animal research. Moreover, when risks are taken with an innovative therapy, the justification lies in the prospect of treating an illness in a patient, whereas, here no patient is at risk until the innovation is employed. Thus, no conscientious physician or Institutional Review Board should approve attempts to use somatic cell nuclear transfer to create a child at this time. For these reasons, prohibitions are warranted on all attempts to produce children through nuclear transfer from a somatic cell at this time.

Even on this point, however, NBAC has noted some difference of opinion. Some argue, for example, that prospective parents are already allowed to conceive, or to carry a conception to term, when there is a significant risk—or even certainty—that the child will suffer from a serious genetic disease. Even when others think such conduct is morally wrong, the parents' right to reproductive freedom takes precedence. Since many of the risks believed to be associated with somatic cell nuclear transfer may be no greater than those associated with genetic disorders, some contend that such cloning should be subject to no more restriction than other forms of reproduction (Brock, 1997).

And, as in any new and experimental clinical procedure, harms cannot be accurately determined until trials are conducted in humans. Law professor John Robertson noted before NBAC on March 13, 1997 that:

“[The] first transfer [into a uterus] of a human [embryo] clone [will occur] before we know whether it will succeed. . . [Some have argued therefore] that the first transfers are somehow unethical. . . experimentation on the resulting child, because one does not know what is going to happen, and one is. . . possibly leading to a

child who could be disabled and have developmental difficulties. . .[But the] child who would result would not have existed but for the procedure at issue, and [if] the intent there is actually to benefit that child by bringing it into being. . .[this] should be classified as experimentation for [the child's] benefit and thus it would fall within recognized exceptions. . .We have a very different set of rules for experimentation intended to benefit [the experimental subject]"(Robertson, 1997).

But the argument that somatic cell nuclear transfer cloning experiments are "beneficial" to the resulting child rest on the notion that it is a "benefit" to be brought into the world as compared to being left unconceived and unborn. This metaphysical argument, in which one is forced to compare existence with non-existence, is problematic. Not only does it require us to compare something unknowable—non-existence—with something else, it also can lead to absurd conclusions if taken to its logical extreme. For example, it would support the argument that there is no degree of pain and suffering that cannot be inflicted on a child, provided that the alternative is never to have been conceived. Even the originator of this line of analysis rejects this conclusion.²

In addition, it is true that the actual risks of physical harm to the child born through somatic cell nuclear transfer cannot be known with certainty unless and until research is conducted on human beings. It is likewise true that if we insisted on absolute guarantees of no risk before we permitted any new medical intervention to be attempted in humans, this would severely hamper if not halt completely the introduction of new therapeutic interventions, including new methods of responding to infertility. The assertion that we should regard attempts at human cloning as "experimentation for [the child's] benefit" is not persuasive.

Cloning and Individuality

In addition to physical harms, many worry about psychological harms associated with such cloning. One of the forms of psychological harm most frequently mentioned is the possible loss of a sense of uniqueness.

Many argue that somatic cell nuclear transfer cloning creates serious issues of identity and individuality and forces us to reconsider how we define ourselves. In his testimony before NBAC on March 13, 1997, Gilbert Meilaender commented on the importance of genetic uniqueness not only for individuals but in the eyes of their parents:

²There is one argument that has been used by several commentators to undermine the apparent significance of potential harms to a child created through somatic cell nuclear transfer (Chadwick 1982; Robertson 1994, 1997; Macklin 1994). The point derives from a general problem, called the non-identity problem, posed by the philosopher Derek Parfit and not originally directed to human cloning (Parfit 1984). This view argues that all the problems of having been born via such cloning are not net harms to the resulting child because they are not worse than no life at all. Parfit does not accept the above argument as sound. Instead, he believes that if one could have a different child without these burdens (for example, by using a different method of reproduction) there is as strong a moral reason to do so (Brock 1995).

“Our children begin with a kind of genetic independence of us, their parents. They replicate neither their father nor their mother. That is a reminder of the independence that we must eventually grant to them and for which it is our duty to prepare them. To lose even in principle this sense of the child as gift will not be good for children”(Meilaender, 1997).

The concept of creating a genetic twin, although separated in time, is one aspect of somatic cell nuclear transfer cloning that most find both troubling and fascinating. The phenomenon of identical twins has intrigued human cultures across the globe, and throughout history (Schwartz, 1996). It is easy to understand why identical twins hold such fascination. Common experience demonstrates how distinctly different twins are, both in personality and in personhood. At the same time, observers cannot help but imbue identical bodies with some expectation that identical persons occupy those bodies, since body and personality remain intertwined in human intuition. With the prospect of somatic cell nuclear transfer cloning comes a scientifically inaccurate but nonetheless instinctive fear of multitudes of identical bodies, each housing personalities that are somehow less than distinct, less unique, and less autonomous than usual.

Is there a moral or human right to a unique identity, and if so would it be violated by this manner of human cloning? For such somatic cell nuclear transfer cloning to violate a right to a unique identity, the relevant sense of identity would have to be genetic identity, that is a right to a unique unrepeatable genome. Even with the same genes, two individuals—for example homozygous twins—are distinct and not identical, so what is intended must be the various properties and characteristics that make each individual qualitatively unique and different than others. Does having the same genome as another person undermine that unique qualitative identity?

Along these lines of inquiry some question whether reproduction using somatic cell nuclear transfer would violate what philosopher Hans Jonas called a right to ignorance, or what philosopher Joel Feinberg called a right to an open future, or what Martha Nussbaum called the quality of “separateness” (Jonas 1974; Feinberg 1980; Nussbaum, 1990). Jonas argued that human cloning, in which there is a substantial time gap between the beginning of the lives of the earlier and later twin, is fundamentally different from the simultaneous beginning of the lives of homozygous twins that occur in nature. Although contemporaneous twins begin their lives with the same genetic inheritance, they also begin their lives or biographies at the same time, in ignorance of what the twin who shares the same genome will by his or her choices make of his or her life. To whatever extent one's genome determines one's future, each life begins ignorant of what that determination will be, and so remains as free to choose a future as are individuals who do not have a twin. In this line of reasoning, ignorance of the effect of one's genome on one's future is necessary for the spontaneous, free, and authentic construction of a life and self.

A later twin created by cloning, Jonas argues, knows, or at least believes he or she knows, too much about him or herself. For there is already in the world another person, one's earlier twin, who from the same genetic starting point has made the life choices that are still in the later twin's

future. It will seem that one's life has already been lived and played out by another, that one's fate is already determined, and so the later twin will lose the spontaneity of authentically creating and becoming his or her own self. One will lose the sense of human possibility in freely creating one's own future. It is tyrannical, Jonas claims, for the earlier twin to try to determine another's fate in this way.

And even if it is a mistake to believe such crude genetic determinism according to which one's genes determine one's fate, what is important for one's experience of freedom and ability to create a life for oneself is whether one thinks one's future is open and undetermined, and so still to be largely determined by one's own choices. One might try to interpret Jonas' objection so as not to assume either genetic determinism, or a belief in it. A later twin might grant that he or she is not destined to follow in his or her earlier twin's footsteps, but that nevertheless the earlier twin's life would always haunt the later twin, standing as an undue influence on the latter's life, and shaping it in ways to which others' lives are not vulnerable.

In a different context, and without applying it to human cloning, Feinberg has argued for a child's right to an open future. This requires that others raising a child not close off the future possibilities that the child would otherwise have by constructing his or her own life. One way this right to an open future would be violated is to deny even a basic education to a child, and another way might be to create the child as a later twin so that he or she will believe its future has already been set by the choices made and the life lived by the earlier twin.

On the other hand, all of these concerns are not only quite speculative, but are directly related to certain specific cultural values. Someone created through the use of somatic cell nuclear transfer techniques may or may not believe that their future is relatively constrained. Indeed, they may believe the opposite. In addition, quite normal parenting usually involves many constraints on a child's behavior that children may resent. Moreover, Feinberg's argument does not apply, if the belief is false and it can be shown to be false.

Thus, a central difficulty in evaluating the implications for somatic cell nuclear transfer cloning of a right either to ignorance or to an open future, is whether the right is violated merely because the later twin may be likely to believe that its future is already determined, even if that belief is clearly false and supported only by the crudest genetic determinism. Moreover, what such a twin is likely to believe will depend on the facts that emerge and not what scientists and ethicists claim.

Cloning and the Family

Among those concerns that are not focused on arguments about harm to the child are a set of worries about use of such cloning as a means of control. There are concerns, for example, about possibly generating large numbers of people whose life choices are limited by their own constrained self-image or by the constraining expectations of others. From this image of

less-than-autonomous children comes the fear, however misplaced, of technology creating armies of cloned soldiers, each diminished in his or her physical individuality and thereby diminished in their psychological autonomy. Similarly, this expectation of diminished autonomy underlies the eugenic arguments that have led many to speculate about the possibility of cloning “desirable” or “evil” people, ranging from actors to dictators of various stripes to distinguished religious leaders. Complicating matters even further, this misplaced belief in the ability of genes to fully determine behavior and personality amplifies the image, so that in the end one imagines being able to make either armies of complacent workers, crazed soldiers, brilliant musicians, or beatific saints.

Although such fears are based, as noted in Chapter Two, on gross misunderstandings of human biology and psychology, they are nonetheless fears that have been voiced. In addition, these same concerns also manifest themselves in fears that underlie the characterization of somatic cell nuclear transfer cloning as a form of “making” children rather than “begetting” children. With cloning, the total genetic blueprint of the cloned individual is selected and determined by the human artisans. This, according to Kass:

“...would be taking a major step into making man himself simply another one of the man made things. Human nature becomes merely the last part of nature to succumb to the technological project which turns all of nature into raw material at human disposal. . .As with any product of our making, no matter how excellent, the artificer stands above it, not as an equal but as a superior, transcending it by his will and creative prowess” (Kass, 1997).

For many, this kind of relationship is inconsistent with an ideal of parenting, in which parents embrace not only the similarities between themselves and their children but also the differences, and in which they accept not only the developments they sought to bring about through care and teaching but also the serendipitous developments they never planned for or anticipated (Rothenberg, 1997).

Of course, parents already exercise great control over their offspring, through means as varied as contraception to control the timing and spacing of births, to genetic screening and use of donor gametes to avoid genetic disorders, to organized medical and educational interventions to guide physical and intellectual development. These interventions exist along a spectrum of control over development. Somatic cell nuclear transfer cloning, some fear, offers the possibility of virtually complete control over one important aspect of a child’s development, his or her genome, and it is the completeness of this control, even if only over this partial aspect of human development, that is alarming to many people and invokes images of manufacturing children according to specification. The lack of acceptance this implies for children who fail to develop according to expectations, and the dominance it introduces into the parent-child relationship, is viewed by many as fundamentally at odds with the acceptance, unconditional love, and openness characteristic of good parenting. Meilaender addressed both the mystery of reproduction and fears about it veering toward a means of production in his testimony before NBAC:

“But whatever we say of [other reproductive technologies], surely human cloning would be a new and decisive turn on this road. Far more emphatically a kind of production. Far less a surrender to the mystery of the genetic lottery which is the mystery of the child who replicates neither Father nor Mother but incarnates their union. Far more an understanding of the child as a product of human will” (Meilaender, 1997).

Questions are raised, as well, about the effect such interventions will have on a particular child. Will the child himself or herself feel less independent from the nucleus donor than a child ordinarily would from a parent? Will the knowledge of how one’s genetic profile developed in another person at another time leave the child feeling that his character is as predetermined as his eye or hair color? Even if the child feels completely independent of the nucleus donor, will others regard the child as a copy or a successor to that donor? If so, will such expectations on the part of others warp the child’s emerging self understanding?

Finally, some critics of such cloning are concerned that the legal or social status of the child arising from nuclear transfer of somatic cells may be uncertain. For some, the disparity between the child’s genetic and social identity threatens the stability of the family. Is the child who results from somatic cell nuclear transfer the sibling or the child of its parents? The child or the grandchild of its grandparents? From this perspective the child’s psychological and social well-being may be in doubt or even endangered. Ambiguity over parental roles may undermine the child’s sense of identity. It may be harder for a child to achieve independence from a parent who is also his or her twin.

At the same time, others are not persuaded by such objections. Children born through assisted reproductive technologies may also have complicated relationships to genetic, gestational, and rearing parents. Skeptics of this point of view note that there is no evidence that confusion over family roles has harmed children born through assisted reproductive technologies, although the subject has not been carefully studied.

Potential Harms to Important Social Values

Those with grave reservations about somatic cell nuclear transfer cloning ask us to imagine a world in which cloning human beings via somatic cell nuclear transfer were permitted and widely practiced. What kind of people, parents, and children would we become in such a world? Opponents fear that such cloning to create children may disrupt the interconnected web of social values, practices, and institutions that support the healthy growth of children. The use of such cloning techniques might encourage the undesirable attitude that children are to be valued according to how closely they meet parental expectations, rather than loved for their own sake. In this way of looking at families and parenting, certain values are at the heart of those relationships, values such as love, nurturing, loyalty, and steadfastness. In contrast, a world in which such cloning were widely practiced would give, the critics claim, implicit approval to vanity, narcissism, and avarice. To these critics, changes that undermine those deeply prized values should be

avoided if possible. At a minimum, such undesirable changes should not be fostered by public policies.

On the other hand, others are not persuaded by these objections. First, many social observers point out that if strongly held moral values are in decline, there are likely many complex reasons for this, which would not be addressed by a ban on cloning in this fashion. Furthermore, skeptics argue that people can, and do, adapt in socially redeeming ways, to new technologies. In their view, a child born through somatic cell nuclear transfer could be loved and accepted like any other child, and not disrupt important family and kinship relations.

The strength of public reaction, however, reflects a deep concern that somehow many important social values could be harmed in a society where such cloning were widely used. In his testimony before the Commission on March 13, 1997, bioethicist Leon Kass summarized many of the widely held concerns regarding the possibility of cloning human beings via somatic cell nuclear transfer when he noted:

“Almost no one sees any compelling reason for human cloning. Almost everyone anticipates its possible misuses and abuses. Many feel oppressed by the sense that there is nothing we can do to prevent it from happening and this makes the prospect seem all the more revolting. Revulsion is surely not an argument....But ... in crucial cases repugnance is often the emotional bearer of deep wisdom beyond reason’s power fully to articulate it” (Kass, 1997).

But some people, however, argue against relying on moral intuition to set public policy. While it is certainly true that repugnance may be the bearer of wisdom, it may also be the bearer of simple and thoughtless prejudice. In her testimony before NBAC on March 14, 1997, bioethicist Ruth Macklin challenged the inclination to take as axiomatic the proposition that to be born as a result of using these techniques is to be harmed or at least to be wronged:

“Intuition has never been a reliable epistemological method, especially since people notoriously disagree in their moral intuitions. . . If objectors to cloning can identify no greater harm than a supposed affront to the dignity of the human species, that is a flimsy basis on which to erect barriers to scientific research and its applications” (Macklin, 1997).

Nevertheless, opponents assert that this new type of cloning tempts human beings to transgress moral boundaries and to grasp for powers that are properly outside human control. Ancient Greek literature and many Biblical interpretations emphasize that human beings occupy a moral position between other forms of life and the divine. In particular, humans should not consider themselves as omnipotent over nature. From this perspective, respecting limits is to respect the appropriate place of humankind in the universe and to ensure that technology is not allowed to push aside critical social and moral commitments. This view need not be tied to a single religious doctrine, a particular view of God, or even a belief in God. However, these

objections are often expressed in religious terms. For example, critics talk of how the ability to create children through somatic cell nuclear transfer may tempt us to seek immortality, to usurp the role of God, or to violate divine commands.

On the other hand, some observers do not see this type of cloning as dramatically new or extreme, especially when compared to other assisted reproductive technologies. Robertson notes:

“In an important sense cloning is not the most radical thing on the horizon. Much more significant, I think, would be the ability to actually alter or manipulate the genome of offspring. Cloning takes a genome as it is. . .and might replicate it . . . [T]hat is much less ominous than having an ability to take a given genome and either add or take out a gene which could then lead to a child being born with characteristics other than it would have had with the genome it started with” (Robertson, 1997).

Finally, critics have also raised questions about an inappropriate use of scarce resources. The generation of children through somatic cell nuclear transfer would divert scarce resources, including the skills of researchers and clinicians, from more pressing social and medical needs. These considerations about allocation of resources are particularly pertinent if public funds would be involved. In the words of theologian Nancy Duff:

“When considering research into human cloning we must look at the responsible use of limited resources. . .[I]t is mandatory to ask whether other research projects will serve a greater number of people than research on human cloning and take the answer to that seriously” (Duff, testimony, 1997).

Treating People As Objects

Some opponents of somatic cell nuclear cloning fear that the resulting children will be treated as objects rather than as persons. This concern often underlies discussions of whether such cloning amounts to “making” rather than “begetting” children, or whether the child who is created in this manner will be viewed as less than a fully independent moral agent. In sum, will being cloned from the somatic cell of an existing person result in the child being regarded as less of a person whose humanity and dignity would not be fully respected.

One reason this discussion can be hard to capture and to articulate is that certain terms, such as “person,” are used differently by different people.³ What is common to these various

³ Moral philosophers think about personhood when they construct and deploy their views of human choice and moral agency. For Kantians, personhood is about free will and reason. From the point of view of Kantian moral personality, all of us are identical as persons. Philosophers of mind think about personhood when they try to figure out what constitutes personal identity. For many of these philosophers, personal identity means having a continuous life story that incorporates a past and a future for oneself. From the point

views, however, is a shared understanding that being a “person” is different from being the manipulated “object” of other people’s desires and expectations. Writes legal scholar Margaret Radin,

“The person is a subject, a moral agent, autonomous and self-governing. An object is a non-person, not treated as a self-governing moral agent . . . [By] ‘objectification of persons,’ we mean, roughly, “what Kant would not want us to do.”⁴

That is, to objectify a person is to act towards the person without regard for his or her own desires or well-being, as a thing to be valued according to externally imposed standards, and to control the person rather than to engage her or him in a mutually respectful relationship. Objectification, quite simply, is treating the child as an object—a creature less deserving of respect for his or her moral agency. Commodification is sometimes distinguished from objectification and concerns treating persons as commodities, including treating them as a thing that can be exchanged, bought or sold in the marketplace. To those who view the intentional choice by another of one’s genetic makeup as a form of manipulation by others, somatic cell nuclear transfer cloning represents a form of objectification or commodification of the child.

Some may deny that objectification is any more a danger in somatic cell nuclear transfer cloning than in current practices such as genetic screening or, in the future perhaps, gene therapy. These procedures aim either to avoid having a child with a particular condition, or to compensate for a genetic abnormality. But to the extent that the technology is used to benefit the child by, for example, allowing early preventive measures with phenylketonuria, no objectification of the child takes place.

of view of personal identity, all of us are different, unique, as persons. Psychoanalysts think about personhood when they relate the constants of human life and development to broad personality structures. From the psychoanalytic point of view, each of us manifests the same dynamic personality structures, yet no two of us do so in exactly the same way; we are all the same and also all different. Welfare rights activists and human rights activists may think about personhood: what is the minimum of necessary resources for a fully human life? Some medical ethicists think about personhood while trying to decide at what point does life cease to be a human life worth living? Political theorists at times think about personhood in the context of trying to understand what are the basics of individuality that the state should recognize or underwrite? Parents think about personhood: what part do I play in making possible the fullest kind of human-ness for my children?” (Radin, 1995).

⁴ “Kantian ethical thought,” writes Radin, “distinguishes morally between persons and objects. Rational beings possessing free will (persons) are autonomous; the moral law requires that persons be treated as ends, not means. Objects in the natural world that are not rational beings possessing free will are not persons, and may appropriately be used as means by persons. Kant’s view requires that persons, moral agents, not be treated as objects, manipulated at the will of persons. Kant presented his basic principles of ethics in *Immanuel Kant, Groundwork of The Metaphysics of Morals* (1785), translated by H. J. Paton in *The Moral Law* (1948).” [Margaret Radin, “Reflections on Objectification,” 65 *Southern California Law Review* 341 (November 1991), at footnote 4]

When such cloning is undertaken not for any purported benefit of the child himself or herself, but rather to satisfy the vanity of the nucleus donor, or even to serve the need of someone else, such as a dying child in need of a bone marrow donor, then some would argue that it goes yet another step toward diminishing the personhood of the child created in this fashion. The final insult, opponents argue, would come if the child created through somatic cell nuclear transfer is regarded as somehow less than fully equal to the other human beings, due to his or her diminished physical uniqueness and the diminished mystery surrounding some aspects of his or her future, physical development.

Eugenic Concerns

The desire to improve on nature is as old as humankind. It has been played out in agriculture through the breeding of special strains of domesticated animals and plants. With the development of the field of genetics over the past 100 years came the hope that the selection of advantageous inherited characteristics—called eugenics, from the Greek *eugenes* meaning wellborn or noble in heredity—could be as beneficial to humankind as selective breeding in agriculture.

The transfer of directed breeding practices from plants and animals to human beings is inherently problematic, however. To begin, eugenic proposals require that several dubious and offensive assumptions be made. First, that most, if not all people would mold their reproductive behavior to the eugenic plan; in a country that values reproductive freedom, this outcome would be unlikely absent compulsion. Second, that means exist for deciding which human traits and characteristics would be favored, an enterprise that rests on notions of selective human superiority that have long been linked with racist ideology.

Equally important, the whole enterprise of "improving" humankind by eugenic programs oversimplifies the role of genes in determining human traits and characteristics. Little is known about correlation between genes and the sorts of complex, behavioral characteristics that are associated with successful and rewarding human lives; moreover, what little is known indicates that most such characteristics result from complicated interactions among a number of genes and the environment. While cows can be bred to produce more milk and sheep to have softer fleece, the idea of breeding humans to be superior would belong in the realm of science fiction even if one could conceive how to establish the metric of superiority, something that turns not only on the values and prejudices of those who construct the metric but also on the sort of a world they predict these specially bred persons would face.

Nonetheless, at the beginning of this century eugenic ideas were championed by scientific and political leaders and were very popular with the American public. It was not until they were practiced in such a grotesque fashion in Nazi Germany that their danger became apparent. Despite this sordid history and the very real limitations in what genetic selection could be expected to yield, the lure of "improvement" remains very real in the minds of some people. In some ways,

creating people through somatic cell nuclear transfer offers eugenicists a much more powerful tool than any before. In selective breeding programs, such as the "germinal choice" method urged by the geneticist H.J. Muller a generation ago (Kevles, 1995), the outcome depended on the usual "genetic lottery" that occurs each time a sperm fertilizes an egg, fusing their individual genetic heritages into a new individual. Cloning, by contrast, would allow the selection of a desired genetic prototype which would be replicated in each of the "offspring," at least on the level of the genetic material in the cell nucleus.

It might be enough to object to the institution of a program of human eugenic cloning—even a voluntary program—that it would rest on false scientific premises and hence be wasteful and misguided. But that argument might not be sufficient to deter those people who want to push the genetic traits of a population in a particular direction. While acknowledging that a particular set of genes can be expressed in variety of ways and therefore that cloning (or any other form of eugenic selection) does not guarantee a particular phenotypic manifestation of the genes, they might still argue that certain genes provide a better starting point for the next generation than other genes.

The answer to any who would propose to exploit the science of cloning in this way is that the moral problems with a program of human eugenics go far beyond practical objections of infeasibility. Some objections are those that have already been discussed in connection with the possible desire of individuals to use somatic cell nuclear transfer that the creation of a child under such circumstances could result in the child being objectified, could seriously undermine the value that ought to attach to each individual as an end in themselves, and could foster inappropriate efforts to control the course of the child's life according to expectations based on the life of the person who was cloned.

In addition to such objections are those that arise specifically because what is at issue in eugenics is more than just an individual act, it is a collective program. Individual acts may be undertaken for singular and often unknown or even unknowable reasons, whereas a eugenics program would propagate dogma about the sorts of people who are desirable and those who are dispensable. That is a path that humanity has tread before, to its everlasting shame. And it is a path to whose return the science of cloning should never be allowed to give even the slightest support.

Arguments for Maintaining Personal Autonomy and Freedom of Inquiry

Arrayed against these concerns about the societal effects of cloning human beings via somatic cell nuclear transfer are arguments for maintaining individual choice over whether to use the technology. These arguments are made on five separate grounds: first, that there is a general presumption in favor of individual liberty; second, that certain actions, such as human reproduction, are particularly personal and should remain free of constraint; third, as a society we ought not limit the freedom of scientific inquiry; fourth, that there are some reasons to create a child through somatic cell nuclear transfer so compelling they should transcend objections to the

practice even if it should otherwise be prohibited; and finally, that many of the objections to the use of this technique are largely speculative and unproven.

Presumptions in Favor of Personal Autonomy

The presumption in favor of individual liberty stems from a consensus within the United States that one of the most important values we share is a commitment to personal autonomy. In part, this commitment is maintained because of the widespread fear that one's own personal choices might be constrained if subject to collective decision making. To the extent that making a personal choice is a form of personal satisfaction, then the means to maximize our collective satisfaction is to make as many personal choices available as possible (Posner, 1992). In addition, personal autonomy is considered valuable in and of itself, since it is viewed by many as the deepest expression of one's individuality and personality, i.e., the deepest expression of one's self. Thus, commentators have argued that a commitment to individual liberty requires that individuals be left free to create children using somatic cell nuclear transfer if they so choose and if their doing so does not cause significant harms to others (Robertson 1997; Macklin 1997).

But such liberty is too broad in scope to be an uncontroversial moral right (Mill 1859; Rhodes 1995). As many others have pointed out, granting such untethered primacy to autonomy can ignore the possibility of competing values that are held as dear in some or all circumstances. Thus, principles of equality, virtue, nonmaleficence, and benevolence may compete for primacy with the principle of autonomy. In her March 13, 1997 testimony before NBAC, theologian Lisa Cahill asserted that

“...a excessive focus on [autonomy] can prevent us from seeing why other values as well are socially important and protectable and why certain freely chosen practices can still be wrong even if they do not result in immediate or quantifiable harm or direct infringement on the options of other free agents. . .A narrow focus on autonomy to freely choose personally preferred goals undermines our ability to talk together about what would go to make up a good society and what we can do concretely to move towards one.”

Indeed, some analysts, such as legal scholar Mary Ann Glendon (1991) and sociologist Amitai Etzioni (1990) have argued that the rhetoric of rights and personal autonomy has obscured the correlative values of responsibility, duty, and restraint. And, indeed, while personal autonomy is upheld rhetorically as an ideal, it is often also constrained on behalf of the common good, even in the absence of harm to others, both in personal and public life. This still leaves open, however, the question of when, in particular, other values ought to trump the value of personal liberty.

In their book *Democracy and Disagreement* (1996) political theorists Amy Gutmann and Dennis Thompson set forth some guidelines for when moral arguments ought to be allowed to constrain personal liberty. Among them are: (1) a convincing argument that a particular action is wrong, independent of whatever specific harms it might cause, because it violates, for example,

natural law, social convention, or fundamental social values; (2) that the wrong is serious enough to warrant public attention and is otherwise eligible for public regulation; and (3) that regulation or prohibition will not cause more harm than the action that opponents seek to prohibit.

Freedom of Reproductive Choice

While the discussion of social values, above, might satisfy the first two conditions set down by Gutmann and Thompson, the third condition requires more attention in this case. To determine whether prohibition of somatic cell nuclear transfer cloning would cause more harm than it prevents, one must examine the particular kind of choices that would be constrained. Certain actions, it is argued, deserve special protection from collective decision making, and human reproduction is often cited as an example. Reproduction is an intensely personal phenomenon, most often commencing in the intimacy of coitus, and always resulting in the creation of a parental relationship that redefines one's place in the world. Without reproduction, one remains a child and perhaps a sibling. With reproduction—or with its social equivalent, adoption—one becomes a parent, taking on responsibilities for another that necessarily require abandoning some of the personal freedoms enjoyed before. When and how to take on such responsibilities and to change one's life course is necessarily one of the most personal and significant decisions imaginable.

It could be argued that somatic cell nuclear transfer cloning is not covered by the right to reproductive freedom, because whereas assisted reproductive technologies covered by that right are remedies for inability to reproduce sexually, somatic cell nuclear transfer cloning is an entirely new means of reproduction; indeed, its critics see it as radically new and as more a means of the mere “manufacturing of humans” than of reproduction. Its asexual nature, for example, leads some to view it as distinctly different from reproduction, which they view as inherently collaborative and sexual. This led one commentator to note that:

“It would be possible for female lineages to proceed without any male contribution at all and it would be possible for one woman to create her own child using her own ovum and DNA. . . So the child who is truly the child of a single parent would be a genuine revolution in human history and her or his advent should be viewed with immense caution” (Cahill, 1997).

On the other hand, while somatic cell nuclear transfer cloning is a different means of reproduction than sexual reproduction, it is nonetheless a means that can serve individuals' interest in reproducing. If it is not covered by the moral right to reproductive freedom, some argue, that must be not because it is a new means of reproducing, but instead because it has other objectionable moral features, such as eroding human dignity or uniqueness.

Assuming for the sake of discussion that somatic cell nuclear transfer cloning is a form of reproduction, the question remains whether reproductive freedom ought to protect its use. Reproductive freedom includes not only the familiar right to choose not to reproduce, for example by means of contraception, but also the right to reproduce. It is commonly understood to include

the use of various artificial reproductive technologies, such as *in vitro* fertilization, and sperm or egg donation. But the case for permitting the use of a particular means of reproduction is strongest when that means is necessary for particular individuals to be able to procreate at all.

It is possible that somatic cell nuclear transfer cloning could be the only technique for individuals to create a genetically related child, but in other cases different means of procreating would also be possible. When individuals have alternative means of procreating, cloning might be chosen because it replicates a particular individual's genome. The reproductive interest in question then is not simply reproduction itself, but a more specific interest in choosing what kind of children to have.

However, the more a reproductive choice is not simply the determination of one's own life but the determination of the nature of another, as in the case of cloning via somatic cell nuclear transfer, the more the interests of that other person—that is the resulting child—should carry moral weight in decisions that determine its nature (Annas, 1994). In addition to the parents and child, reproduction is also a communal phenomenon. It thrusts a new person into the world, and the whole community has obligations for this new member's well being.

Thus, the decision to reproduce is rife with consequence both to the new person brought into being and to those who will live and interact with that new person. Naturally, this invites communal commentary on the wisdom of when and how this person is brought into being. And while constitutional law has viewed certain aspects of reproductive choice as fundamental rights, discourse is not so constrained. Thus, one is free to argue, as a matter of ethics, that reproductive choices ought to be made in light of communal values, even while accepting that there are administrative and political reasons for avoiding efforts to embody these moral judgements in the form of laws, whose enforcement would intrude the state into the private realm of family life and conjugal relations to an unacceptable degree.

Freedom of Scientific Inquiry

Another argument made against prohibiting efforts to attempt to create a child through somatic cell nuclear transfer focuses on the need to encourage research and scientific advances. There is no doubt that the freedom of the ethical and responsible pursuit of knowledge has been an enduring American value, supported by scientists and non-scientists alike. Historically, scientific inquiry has been protected and even encouraged because of the great social benefit the public recognizes in maintaining the “sanctity of knowledge and the value of intellectual

freedom.”^{5 6} But the importance we attach to free scientific inquiry does not mean the pursuit of science without moral constraints. International statements about the ethics of research with human subjects, such as the Nuremberg Code and the Declaration of Helsinki, make it abundantly clear that science, however valuable, must, as scientists and non-scientists agree, observe important moral boundaries. Scientific research, for example, must not endanger community safety or the rights or interests of its human subjects. Likewise, it must not inflict unnecessary suffering on animals.

Thus, both the federal government and the states already regulate the researcher's methods in order to protect the rights of research subjects and community safety. Research may be restricted, for example, to protect the subject's autonomy by requiring informed consent, and by reviewing the choice of who should serve as research subjects against principles of justice. Thus, for example, if the government can show that restrictions on cloning and cloning technology are sufficiently important to the general well-being of individuals or society, such restrictions are likely to be upheld as legitimate, constitutional governmental actions, even if scientists were held to have a First Amendment right of scientific inquiry (Robertson, 1977).

Therefore, even if scientific inquiry were found to be a constitutionally protected activity, the government could regulate to protect against compelling harms, such as the current physical risks posed by the prospective use of somatic cell nuclear transfer techniques to create children. The freedom to pursue knowledge is distinguishable from the right to choose the method for achieving that knowledge, since the method itself may permissibly be regulated. Although the government may not prohibit research in an attempt to prevent the development of new knowledge, it may and should restrict or prohibit the means used by researchers if they involve sufficient harm to others (Robertson, 1977). Ultimately, researchers themselves are responsible for maintaining ethical and scientific standards and must strive to integrate the two in their work.

Consideration of Exceptional Cases

Even as a matter of ethics, rather than of law, it is quite possible to argue against a wholesale condemnation of somatic cell nuclear transfer cloning of human beings. Some circumstances have been identified in which the choice to create a child in this manner would be understandable, or even, as some have argued, desirable. Consider the following examples:

- A couple wishes to have children, but both adults are carriers of a lethal recessive gene. Rather than risk the one in four chance of conceiving a child who will suffer a short and

⁵Branzburg v. Hayes, 408 U.S. 665, 705 (1972). Similarly, the Supreme Court stated in Meyer v. Nebraska that the right to liberty guaranteed by the Fourteenth Amendment encompassed freedom to "acquire useful knowledge . . . and generally to enjoy those privileges long recognized at common law as essential to the orderly pursuit of happiness by free men."

⁶Henley v. Wise, 303 F.Supp. 62 (N.D. Ind. 1969).

painful existence, the couple considers the alternatives: to forgo rearing children; to adopt; to use prenatal diagnosis and selective abortion; to use donor gametes free of the recessive trait; or to use the cells of one of the adults and attempt to clone a child. To avoid donor gametes and selective abortion, while maintaining a genetic tie to their child, they opt for cloning.

- A family is in a terrible accident. The father is killed, and the only child, an infant, is dying. The mother decides to use some cells from the dying infant in an attempt to use somatic cell nuclear transfer to create a new child. It is the only way she can raise a child who is the biological offspring of her late husband.
- The parents of a terminally ill child are told that only a bone marrow transplant can save the child's life. With no other donor available, the parents attempt to clone a human being from the cells of the dying child. If successful, the new child will be a perfect match for bone marrow transplant, and can be used as a donor without significant risk or discomfort. The net result: two healthy children, loved by their parents, who happen to be identical twins of different ages.

In each of these examples, the impulse to attempt such cloning can be understood. In the first example, the possible complications caused by having a child who is genetically identical to one of the parents is weighed against the value of avoiding selective abortion or of keeping the marital relationship free of the ghost of an anonymous sperm or egg donor. In the second, the psychological complexities of bearing a "replacement" child are weighed against the grief of losing not only a husband but also the possibility of a child who will grow up as a physical reminder of that love. While some may argue that neither case is compelling, because infertility and grief are part of human existence, the intensely personal nature of that infertility or grief argues for an equally personal decision about how to respond. The third case makes what is probably the strongest possible case for cloning a human being, as it demonstrates how this technology could be used for lifesaving purposes. Indeed, the tragedy of allowing the sick child to die because of a moral or political objection to such cloning overall merely points up the difficulty of making policy in this area.

Some would argue that what is more important in these scenarios is how the resulting child will be viewed. Macklin argues that:

"The ethics of these situations must be judged by the way in which the parents nurture and rear the resulting child and whether they bestow the same love and affection on a child brought into existence by a technique of assisted reproduction as they would on a child born in the usual way" (Macklin, 1997).

It may be that a policy which prohibited the creation of children through somatic cell nuclear transfer cloning would ban a handful of scenarios for which some people feel sympathy.

Nonetheless, it may be necessary to forbid the practice overall in order to protect other crucial societal values.

Moral Reasoning and Public Policies

“It is certainly possible that there may be no substantial benefits to society that would result if human cloning were to become a reality. Yet this would constitute a good argument for prohibition only if considerable harms are a likely consequence. We need a realistic portrait, not a recitation of worst case science fiction scenarios before we may conclude that the harms of allowing cloning to proceed in a research context and even beyond are so great that even with regulations and oversight consummate evil will result” (Ruth Macklin, 1997).

“We should proceed with research into human cloning only if compelling arguments can be made for its potential benefits” (Nancy Duff, 1997).

Some citizens may be persuaded that the harms and wrongs described in this chapter are ethically compelling and might be decisive reasons never to permit cloning via somatic cell nuclear transfer. Others may be less certain about the significance of the objections, and unwilling to conclude that somatic cell nuclear transfer cloning would be ethically impermissible, if and when the risks could be shown to be minimal. This range of views is reflected in the testimony, letters, and commissioned papers reviewed by NBAC, and is also characteristic of the commissioners themselves.

NBAC was asked to consider whether public policy should permit, regulate, or prohibit the creation of children through somatic cell nuclear transfer. The formation of public policy in an area as sensitive as procreation requires careful thought and measured deliberation. In the United States, governmental policies that prohibit or regulate human actions require justification because of a general presumption against governmental interference in individual activities. This presumption can be rebutted under various circumstances for a variety of reasons. Many critics of cloning via somatic cell nuclear transfer are concerned, however, that this initial presumption of no interference with individual actions will lead to unwise policies.

Some considerations carry more weight in the public policy arena than they do in the formation of individual judgments. In setting public policy, for example, pragmatic and procedural considerations often, quite appropriately, carry greater weight than in deciding private choices. One reason for this is that the burden of enforcing public policies must be considered. For example, it is extremely intrusive to monitor reproductive decisions by individuals and couples. It may be impractical to have a policy that allows some cases of somatic cell nuclear transfer to create a child, while prohibiting others, even though we make such judgments privately about individual actions. Furthermore, trying to distinguish acceptable from unacceptable reasons will be difficult. People might be led to misrepresent their true reasons in order to fit whatever is deemed “acceptable.”

Moreover, the reasoning used to evaluate the desirability of proposed public policies regarding the creation of children through somatic cell nuclear transfer differs somewhat from the reasoning employed in making private decisions. When individuals make judgments they may rely on many sources of wisdom and knowledge, including their religious faith and moral intuitions. People will use their understanding of morality to decide what they should and should not do, as well as to judge the actions of others.

Those engaged in moral discourse about public policy, however, must move beyond such personal considerations, however deeply felt, and develop coherent arguments that will persuade many others to accept a particular point of view. As a result, it is useful to formulate moral convictions in ways that most people can understand and reflect upon. In a pluralistic society, there is no easy way to determine when and which governmental interventions are warranted. No algorithm clearly indicates whether the arguments for governmental intervention in a particular situation are stronger than the arguments against such interventions. Instead, we must engage in moral discourse, debate, and argument in a process of public deliberation. Although closure must be reached, and decisions made, even if there is no consensus, our society has only just begun to reflect seriously on the possibility of creating children through somatic cell nuclear transfer. It may be premature to come to closure on some issues because so little time has been devoted to the issue.

Thus, the ethics of making policy, as opposed to the ethics of cloning itself, requires us to return to the guidelines set forth by scholars such as Gutmann and Thompson: are the moral concerns sufficiently strong to justify prohibition or regulation? If so, is the price we pay in the form of constraints on personal liberty or the abridgement of legally protected rights acceptable? Can individual cases be treated as exceptions? Or will making exceptions create more problems, in the form of intrusive inquiries into people's motives, for example, such that making the exceptions causes more harm than good? It is difficult to answer these questions with certainty.

Conclusions

In summary, the Commission reached several conclusions in considering the appropriateness of public policies regarding the creation of children through somatic cell nuclear transfer. First and foremost, creating children in this manner is unethical at this time because available scientific evidence indicates that such techniques are not safe at this time. Even if concerns about safety are resolved, however, significant concerns remain about the negative impact of the use of such a technology on both individuals and society. Public opinion on this issue may remain divided. Some people believe that cloning through somatic cell nuclear transfer will always be unethical because it undermines important social values and will always risk causing psychological or other harms to the resulting child. In addition, although the Commission acknowledged that there are cases for which the use of such cloning might be considered desirable by some people, overall these cases were insufficiently compelling to justify proceeding with the use of such techniques. Finally, the Commission was not persuaded by objections to a prohibition

against such cloning which were based, in part, on the expectation that its use is unlikely to be widespread and, in part, on the belief that many of the assumed harms are purely speculative.

Finally, many scenarios of creating children through somatic cell nuclear transfer are based on the serious misconception that selecting a child's genetic makeup is equivalent to selecting the child's traits or accomplishments. A benefit of more widespread discussion of such cloning would be a clearer recognition that a person's traits and achievements depend heavily on education, training, and the social environment, as well as on genes. Should this type of cloning proceed, however, any children born as a result of this technique should be treated as having the same rights and moral status as any other human being.

Clearly, there is a need for further public deliberation on the serious moral concerns raised by the prospect of cloning human beings. As the Commission proceeded in its review, the members learned from listening to the public and to each other. Many important issues remain unresolved, such as the nature and scope of our moral interest in the freedom to make procreative choices, and whether that freedom should encompass creating a child through somatic cell nuclear transfer cloning. The Commission believes that it is essential to try to understand the diverse reactions to such cloning and the ethical arguments for and against various policies regarding its use. This report is only the beginning of a public process to assess the impact of this new technology.

References

- Annas, G.J, "Regulatory models for human embryo cloning: The free market, professional guidelines, and government restrictions," *Kennedy Institute of Ethics Journal* (4)3:235-249, 1994.
- Brock, D., "Cloning Human Beings: An Assessment of the Ethical Issues Pro and Con," paper prepared for NBAC, 1997.
- Brock, D.W. "The non-identity problem and genetic harm," *Bioethics* 9:269-275, 1995.
- Cahill, L., Testimony presented to the National Bioethics Advisory Commission, March 13, 1997.
- Chadwick, R.F., "Cloning," *Philosophy* 57: 201-209, 1982.
- Coleman, "Playing God or playing scientist: A constitutional analysis of laws banning embryological procedures," *27 Pacific Law Journal* 1331, 1996.
- Duff, N., "Theological Reflections on Human Cloning," Testimony presented to the National Bioethics Advisory Commission, March 13, 1997.
- Etzioni, A., *The Moral Dimension* (NY: The Free Press, 1990).
- Feinberg, J., "The child's right to an open future," in *Whose Child? Children's Rights, Parental Authority, and State Power*, W.Aiken and H. LaFollette (eds.) (Totowa, NJ: Rowman and Littlefield, 1980).
- Glendon, M.A., *Rights Talk* (New York: The Free Press, 1991).
- Gutmann, A., and D. Thompson, *Democracy and Disagreement* (Cambridge, MA: Belknap Press, 1996).
- Jonas, H., *Philosophical Essays: From Ancient Creed to Technological Man* (Englewood Cliffs, N.J.: Prentice-Hall, 1974).
- Kass, L., "Why We Should Ban the Cloning of Human Beings," Testimony presented to the National Bioethics Advisory Commission, March 13, 1997.
- Kevles, D.J., *In the Name of Eugenics* (Cambridge, MA: Harvard University Press, 1995).
- Meilaender, G., "Remarks on Human Cloning to the National Bioethics Advisory Commission, Testimony presented to the National Bioethics Advisory Commission, March 13, 1997.

- Macklin, R., "Why We Should Regulate—But Not Ban—the Cloning of Human Beings,"
Testimony presented to the National Bioethics Advisory Commission, March 14, 1997.
- Macklin, R., "Splitting embryos on the slippery slope: Ethics and public policy," *Kennedy Institute of Ethics Journal* 4: 209-226, 1994.
- Mill, J.S., *On Liberty* (Indianapolis, IN: Bobbs-Merrill Publishing, 1859).
- National Institutes of Health, *Report of the Human Embryo Research Panel* (Bethesda, MD: National Institutes of Health, 1994).
- Nussbaum, M.C., "Aristotelian social democracy," in *Liberalism and the Good* 203, R. Bruce Douglass, et al., (eds.), pp. 217-226, 1990.
- Parfit, D., *Reasons and Persons* (Oxford: Oxford University Press, 1984).
- Posner, R., *Sex and Reason* (Cambridge, MA: Harvard University Press, 1992).
- Radin, M., "Reflections on Objectification," 65 *Southern California Law Review* 341 (November 1991).
- Radin, M., "The Colin Ruagh Thomas O'Fallon Memorial Lecture on Personhood," 74 *Oregon Law Review* 423 (Summer 1995).
- Rhodes, R. "Clones, harms, and rights," *Cambridge Quarterly of Healthcare Ethics* 4:285-290, 1995.
- Robertson, J.A., "A Ban on Cloning and Cloning Research is Unjustified," Testimony Presented to the National Bioethics Advisory Commission, March 14, 1997.
- Robertson, J.A., "The question of human cloning," *Hastings Center Report* 24:6-14, 1994.
- Robertson, "The scientist's right to research: A constitutional analysis, 51 *Southern California Law Review* 1203, 1977.
- Rothenberg, K., Testimony before the Senate Committee on Labor and Human Resources, March 12, 1997.
- Schwartz, H., *The Culture of Copy* (New York: Zone Books, 1996).

Chapter Five

LEGAL AND POLICY CONSIDERATIONS

The public policies recommended with respect to the creation of a child using somatic cell nuclear transfer reflect the Commission's best judgment about both the ethics of attempting such an experiment and the Commission's view of American traditions regarding limitations on individual actions in the name of the common good. At present, the use of this technique to create a child would be a premature experiment that exposes the developing child to unacceptable risks. This in itself is sufficient to justify a prohibition on attempts to clone human beings at this time, even if such efforts were to be characterized as the exercise of a fundamental right to attempt to procreate. More speculative psychological harms to the child and effects on the moral, religious, and cultural values of society may or may not be enough to justify prohibitions in the future, and more time is needed for discussion of these concerns. The prohibition on cloning human beings via somatic cell nuclear transfer could be effectuated directly, through federal legislation, or indirectly, by way of a collection of efforts aimed at deterring such experiments. Such efforts could include voluntary cooperation by the private sector, both research and clinical, in a moratorium on such experiments and a continued prohibition of the use of federal funds to support such experiments. Enhancement of protections for human subjects of medical research and cooperation with other nations in the enforcement of any common elements of our respective policies could strengthen any of these measures.

* * * * *

This chapter briefly reviews existing and proposed laws and policies that would affect efforts to clone human beings using somatic cell nuclear transfer, as well as the potential constitutional challenges that might be raised if such efforts are restricted.¹

Almost immediately after the announcement of Dolly's birth, legislation was introduced in the Congress and in approximately a dozen states, aimed at prohibiting all or some research on human cloning (see table 1). Some of the bills would prohibit the use of somatic cell nuclear transfer cloning to create a child; others would also, either deliberately or inadvertently, prohibit research on cloning human DNA sequences or cell lines. The current moratorium on the use of federal funds for cloning human beings in this manner has provided an opportunity for additional analysis of the potential risks and benefits of creating children through somatic cell nuclear transfer, its current legal status, and the potential constitutional challenges that might be raised if new legislation is enacted to restrict such acts.

¹ To support the Commission's review, a commissioned paper, "The Current and Future Legal Status of Cloning," was prepared by Lori Andrews, Chicago-Kent College of Law. In addition, NBAC commissioned a review of research moratoria, "Do Research Moratoria Work?" prepared by Robert M. Cook-Deegan, and a review of international responses, "Cloning: An International Comparative Perspective," prepared by Bartha Knoppers, University of Montreal.

Laws Affecting Efforts to Clone a Human Being

At present, there is no law in the United States directly addressing attempts to create a child through somatic cell nuclear transfer, although a variety of state and federal laws and policies do have some application.

Federal Law

Federal law already requires that clinics using assisted reproduction techniques, such as *in vitro* fertilization, be monitored. The requirement would appear to apply, as well, to efforts to use somatic cell nuclear transfer cloning to create a child. This statute, the Fertility Clinic Success Rate and Certification Act of 1992,² covers all laboratories and treatments that involve manipulation of human eggs and embryos, and requires that rates of success at achieving pregnancies be reported to the Department of Health and Human Services (DHHS) for publication in a consumer guide. It also directs DHHS to develop a model program for inspection and certification of laboratories that use human embryos, to be implemented by the states.

As this statute is implemented, any clinic or laboratory involved in attempts to initiate pregnancies by somatic cell nuclear transfer cloning should be identifiable to the federal government, and the outcomes of its efforts known to the public. As states move to implement the inspection and certification aspects of the law, a mechanism would exist to prevent attempts to use the technology, if it is shown to be ineffective or dangerous for the tissue donor or resulting child.

Federal regulations governing the use of human beings in research also restrict the conduct or funding of any research aimed at cloning human beings. Research that is conducted with federal funds or at institutions that have executed a “multiple assurance agreement” with the federal government is subject to these regulatory provisions, aimed at ensuring that human subjects are not exposed to unreasonably risky experiments and are enrolled in research only after giving informed consent.³ Enforcement of these protections lies primarily in the hands of “Institutional Review Boards,” [“IRBs”] committees appointed by institutions (such as universities) where research is conducted. IRBs review experiments before people can be enrolled. To the extent that efforts to clone human beings take place at institutions subject to these regulations or in experiments funded by the federal government, any serious question about the physical harms that might result would make it difficult for such experimentation to be approved.

With regard to federal research funding, President Clinton announced in 1994 that the National Institutes of Health (NIH) should not finance any research that involves creating embryos

²42 U.S.C.A. Sec. 263a-1 et seq

³45 C.F.R. Part 46

solely for research that would result in their destruction.⁴ Furthermore, Congress has passed prohibitions on the use of FY96 and FY97 funds appropriated to the Departments of Labor, Education, and HHS for any research that involves exposing embryos to risk of destruction for non-therapeutic research.⁵ The net effect of these policies is to eliminate virtually all federal funding for research to perfect methods for cloning human beings, as even research aimed at initiating a pregnancy would probably involve creating and destroying many embryos that fail to develop normally.

State Laws

While these restrictions prohibit only federally funded research, a number of state laws regarding the management of embryos arguably could restrict even privately funded research.⁶ By and large, however, states do not have legislation directly regulating assisted reproduction techniques, leaving state medical malpractice law as the primary means for regulating clinical application of the technology.⁷

Malpractice law operates most effectively when agreement exists within the medical profession about the indications and contraindications for a particular procedure, as well as about the methods by which the procedure is appropriately carried out. For an entirely new procedure, agreement on these points may be lacking, although sometimes consensus exists within the

⁴“Statement of the President on NIH Recommendations Regarding Human Embryo Research,” U.S. Newswire (Dec. 2, 1994).

⁵P.L. 104-91 and P.L. 104-208.

⁶Ten states have laws regulating research and/or experimentation on conceptuses, embryos, fetuses or unborn children that use broad enough language to include early stage conceptuses. Fla. Stat. Ann. § 390.001(6) (West 1993); La. Rev. Stat. Ann. § 9:121 *et seq.* (West 1991); Me. Rev. Stat. Ann. tit. 22, § 1593 (West 1992); Mass. Gen. Laws Ann. ch. 112, § 12J (West 1996); Mich. Comp. Laws Ann. § 333.2685 *et seq.* (West Supp. 1997); Minn. Stat. Ann. § 145.421 (West 1989); N.D. Cent. Code § 14-02.2-01 (1991); N.H. Rev. Stat. Ann. § 168-B:15 (Supp. 1996); Pa. Cons. Stat. § 3216 (West Supp. 1996); R.I. Gen. Laws § 11-54-1 (1994).

⁷If cloning is considered to be a form of fertilization, questions arise regarding whether state laws setting standards for who may perform *in vitro* fertilization will cover the practice. Certain laws governing reporting, the qualifications of personnel, and so forth, will be applicable to researchers. A New Hampshire law, for example, requires counseling in advance of *in vitro* fertilization and limits the procedure to participants over age 21 (which, if applied to cloning, might prohibit the use of DNA from a minor child). Pennsylvania has a reporting requirement which mandates that anyone performing *in vitro* fertilization file quarterly reports with the Department of Health describing such facts as the number of embryos destroyed and discarded and the number of women in whom embryos are implanted. Louisiana’s law requires that *in vitro* fertilization shall only be undertaken by practitioners and facilities meeting the standards of the American College of Obstetricians and Gynecologists (ACOG) and the American Fertility Society (AFS) (currently, the American Society for Reproductive Medicine). La. Rev. Stat. Ann. § 9:128 (West 1991).

profession that any attempt to use a new procedure would be premature in light of the existing, pre-clinical data.

State laws governing family relationships would also be applicable if efforts to clone human beings were successful. But paternity acts, surrogacy statutes, and egg donation statutes are not necessarily broad enough to address the kinship relationships involved in cloning human beings. The use of this technique would result in a child having as many as four individuals with claims to parental status based on some aspect of genetic connection: the person from whom the cell nucleus was derived, that individual's genetic parents, and the woman contributing the enucleated egg cell which contains a small fraction of DNA in the cytoplasmic mitochondria. In addition, if the egg with the transferred nucleic material is implanted in a gestational mother, the child will have two other potential parents: the gestational mother,⁸ and if she is married, her husband.⁹ Finally, the intended rearing parents could be unrelated to the individuals whose egg or nucleus was used, or to the gestational mother. The contributors to such cloning arrangements will have various, as yet ill-defined, legal rights and responsibilities with respect to the resulting child (Andrews, 1997).

Overall, existing law would severely restrict public funding for efforts to clone human beings; would monitor most efforts to clone human beings for safety and efficacy; and would discourage premature experimentation. It would not, however, prohibit all such efforts. Further, if an attempt to clone a human being were successful, then existing law would struggle to characterize the family relationships that ensue.

Constitutional Limitations on Policy Formulation

Although the potential ability to clone human beings by somatic cell nuclear transfer engendered a great deal of discussion,¹⁰ the formation of appropriate public policy with respect to

⁸In many states, the woman who gives birth is considered to be the legal mother and her husband the legal father of any resulting child. Under statutes in Arizona and Utah, this holds true even when the surrogate is gestating an embryo with no genetic relationship to her. Only in Florida, New Hampshire, North Dakota and Virginia do court-approved gestational surrogacy arrangements result in the intended rearing parents—not the surrogate—being viewed as the legal parents.

⁹The latter often will have rights (even though he has no biological connection to the child) based on the common law presumption that if a woman gives birth within marriage, her husband is the child's legal father, or in some states, based on specific statutes holding that the surrogate and her husband are the legal parents of a child she has gestated regardless of their genetic contribution. See, e.g., Ariz. Rev. Stat. § 25-218 (1996).

¹⁰See, e.g., *Los Angeles Times*, February 25, 1997, page 6, "Next, Really Prolific Cows: Scientists Clone a Sheep, but We Needn't Fret the Doomsday Scenarios"; *The New York Times*, February 25, 1997, Section A; page 26; "Cloning for Good or Evil"; *The Houston Chronicle*, February 25, 1997, Outlook; page 19, "Dolly's birth is father to some worrying musings," Otis Pike; *The Record*, February 25, 1997, page L10,

cloning of human beings in this manner depends on more than the potential benefits and harms of reproductive cloning itself. It also depends on the traditions, customs, and principles of constitutional law that guide public policy making in the United States. These include such important factors as:

- a) a presumption in favor of individual freedom of action, absent strong arguments to the contrary based on the common good and the need to protect others from harm;
- b) the requirement that arguments against individual freedom of action be made in terms as convincing and understandable as possible to all those who will be affected, recognizing that U.S. citizens are of various religious faiths and cultural traditions;
- c) the requirement that liberty be constrained as little as needed while serving the public interest;

"Of Sheep and Men; Before Building a Better Beast, Think Twice; *The San Diego Union-Tribune*, February 25, 1997, page B-6, "Amazing breakthrough: Cloning of sheep has remarkable implications"; *Wall Street Journal*, February 25, 1997, Section A; page 22, "Review & Outlook: Listening to the Lamb"; *The Arizona Republic*, February 26, 1997, page B4, "Cloning Question; The Mysteries of Life"; *The Florida Times-Union*, February 26, 1997, page A10, "No need for panic"; *Miami Herald*, February 26, 1997, Section A; page 16, "God's Work; Man's Hands"; *The Morning Call*, February 26, 1997, page A16, "'Dolly' Opens New Vistas For Mankind"; *St. Petersburg Times*, February 26, 1997, page 14A, "Rules for cloning needed"; *The Buffalo News*, February 27, 1997, page 2B, "Ready or Not, Cloning Has Arrived; Don't Lose Time Banning it in Humans"; *Dayton Daily News*, February 27, 1997, page 1a, "Animal Cloning Calls for Human Restraint"; *Philadelphia Inquirer*, February 27, 1997, page 19, "Don't Be Too Hasty With Laws on Cloning," by James K Glassman; *The San Francisco Examiner*, February 27, 1997, page A20, "Hello Dolly: The cloning of a lamb from a sheep cell opens up a new era of nervous jokes, profound questions and athletic opportunity"; *The Augusta (Ga.) Chronicle*, February 28, 1997, page A4, "Ban Human Cloning"; *The State Journal-Register* (Springfield, IL), March 2, 1997, page 16, "Cloning of sheep holds remarkable implications"; *The Baltimore Sun*, March 3, 1997, page 8A, "More of you and me?; Hello, Dolly: Replicating a sheep raises concerns about cloning humans"; *The Indianapolis News*, March 4, 1997, page A6, "Wolves in sheep's cloning"; *The Spokesman-Review* (Spokane, WA), March 7, 1997, page B6, "Cloning Tempts Our Darker Sides; Ban Research; We Won't Resist the Urge to Turn Humans into Instruments," D.F. Oliveria; *The Spokesman-Review* (Spokane, WA), March 7, 1997, page B6, "Cloning Offers Hope, Not Evil; Don't Be Afraid; Cloning Research Offers Hope to Solve Genetic Mysteries," Rebecca Nappi; *The Times-Picayune*, March 10, 1997, page B6, "Cloning Begets Questions"; *Dayton Daily News*, March 10, 1997, page 6A, "Fear of Clones Itself a Threat"; *The Orange County Register*, March 10, 1997, page B06, "Vital questions"; *Los Angeles Times*, March 13, 1997, page 8, "Don't Rush Anti-cloning Laws; Concerns Are Real, but Legislation Needs Expert Input," *The Nashville Banner*, March 19, 1997, page A8, "Frist's note of caution; Don't be too hasty, he says, to pass law on cloning"; *The Nation*, March 24, 1997, No. 11, Vol. 264; Pg. 4; ISSN, "Irreplaceable ewe; cloning of a sheep;" Editorial, Hubbard, Ruth; *The New York Times*, April 1, 1997, page 22, "Cloning as an Anticlimax," Philip M. Boffey; Information Bank Abstracts, *Wall Street Journal*, May 2, 1997, page 14, "Will Cloning Beget Disaster?"

- d) allowing individual deviation from the applicable public policy when a compelling need is shown, whenever possible;
- e) restraint in the exercise of federal powers with regard to areas traditionally governed by diverse state laws and policies; and
- f) coordination with common policies set in other nations, where appropriate.

Liberty and Limited Federal Powers

The presumption in favor of individual freedom of action cannot be interpreted simplistically. A focus on rights to the exclusion of responsibility leaves us in a situation where, in the words of legal scholar Mary Ann Glendon, “we can barely find the words to speak of indirect harms, cumulative injury, or damages that appear only long after the acts that precipitated them” (Glendon, 1991).

Nonetheless, from the writings of Locke to the writings of the United States Supreme Court, the American tradition has been to assume a freedom to act absent a specific, justifiable prohibition. This tradition is enshrined in the constitutional language of liberty used in case law, ranging from freedom from unreasonable searches and seizures to freedom to refuse medical treatment. But the liberty enshrined in American tradition and constitutional law is not unfettered; rather, it is the ordered liberty of a social compact. To ensure the good order of society, one person’s liberty may be limited when its exercise would limit the liberty of another, or would otherwise undermine important social values.

It is for this reason that an individual’s actions may be limited when they would directly harm another. This principle can be applied even when the harm will not be experienced by a currently living person. Thus, on occasion, American courts have recognized that even actions taken prior to the conception of a child might lead to legal responsibility for that child’s health costs, if the actions were unreasonable and avoidable.¹¹

On this basis alone, efforts at this time to create a child via somatic cell nuclear transfer may well be inappropriate, since there is widespread consensus that such a step would be dangerous and premature before a great deal of further animal research is conducted.

Morality and Public Policy Formulation

Concerns about the potential impact of cloning human beings through somatic cell nuclear transfer on public and private values and morale are quite real, but nonetheless difficult to articulate with precision. These ethical and theological concerns (as discussed in Chapter 3) focus on effects on self-identity, human dignity, privacy, autonomy, and kinship relations.

¹¹See, e.g., *Curlender v. Bio-Science Laboratories*, 165 Cal. Rptr. 477 (Ct. App. 1980).

Americans share some but not all of their ethical and cultural traditions, and no single set of approaches that balances conflicting values in particular ways enjoys universal acceptance (Brock, 1995). Some theological analyses provide answers to their adherents, but these are incapable of serving as the sole basis for policy making in a religiously diverse nation committed to separation of church and state.¹² Further, the absence of an agreed upon methodology in moral philosophy or bioethics for resolving disputes among competing ethical theories and conflicting values means that no analytical argument can be persuasive to every person (Brock, 1995). Nonetheless, the instinctive distrust with which much of the American public greeted the prospect of cloning is necessarily a significant factor. No suggested public policy can hope to gather support and compliance in the absence of either consensus or persuasive argumentation.

Many of the objections described above are based upon predictions of the widespread effects on society should this type of cloning become a frequent practice. Thus, they are arguments not only about the morality of cloning itself, but also about the need to avoid it even in arguably compelling cases, lest the accumulation of such individual cases lead to widespread practice that could undermine—as many who testified before NBAC have put it—the very meaning of being human.

Members of the Commission could not come to a common evaluation of each of these objections, as they are partly speculative, partly theological, and partly based on particular values or world views that are commonly, but nonetheless not universally, shared by all Americans. On the other hand, the collective force of these objections makes a strong *prima facie* case for a political judgment that creating a child in this manner would violate the deeply held views of many Americans.

Fundamental Liberties, Procreation and Cloning

But while such arguments may make a strong political case for prohibiting this type of cloning, American law occasionally demands more. Specifically, while any rational reason will suffice for government limitation of ordinary individual liberties, such as the right to drive or to operate a business, the Constitution demands a more compelling reason when a more important

¹²"[I]n order to be legitimate, the State's interest ... must be secular; consistent with the First Amendment the State may not promote a theological or sectarian interest. *Planned Parenthood of Southeastern Pennsylvania v. Casey*, 112 S. Ct. 2791, 120 L.Ed 2d 674, 739 (1992) (Stevens, J. concurring in part and dissenting in part). See also *Thornburgh v. American College of Obstetricians and Gynecologists*, 476 U.S. 747, 778 (1986) (Stevens, J. concurring); see generally *Webster v. Reproductive Health Services*, 492 U.S. 490, 563-572 (1989) (Stevens, J., concurring in part and dissenting in part).

When applied to ethical decision making, one philosopher notes: "Morality's ambition is, or at least ought to be, to provide a system of conduct under which everyone can live with a sense of mutual justifiability. This follows from the conditions of political legitimacy. We do not live in a theocracy, where some people are thought to have a privileged and direct line to moral truth." (Nagel 1995)

kind of right is infringed. Then, any limitation must serve a compelling purpose and must be drawn as narrowly as possible, so as to infringe upon individuals only as needed.

This is the case when fundamental liberties are at stake. Fundamental liberties have been defined by the Supreme Court as those that are specifically mentioned in the Constitution, for example, the right to free speech; those so deeply rooted in our culture and history as to be assumed by the public as beyond casual governmental interference; and those that are so basic they are necessary to a system of ordered liberty.

Thus, to determine if the arguments put forth are sufficient to justify a prohibition constitutionally, as well as politically, it is necessary to examine whether the choice to create a child via somatic cell nuclear transfer cloning would be viewed as a fundamental liberty. Since such cloning, if successful, would involve bringing children into the world, it is quite possible that one could characterize it as a form of procreation, for which the courts have carved out large areas of special protection since the “bearing and begetting” of children has been characterized as a fundamental right.

The right to make decisions about whether or not to bear children was first constitutionally protected under the constitutional right to privacy.¹³ More recently, the Court has reaffirmed the “recognized protection accorded to liberty relating to intimate relationships, the family, and decisions about whether to bear and beget a child.”¹⁴ A federal district court has interpreted this right to make procreative decisions to include the right of an infertile couple to undergo medically assisted reproduction, including *in vitro* fertilization and the use of a donated embryo, stating:

It takes no great leap of logic to see that within the cluster of constitutionally protected choices that includes the right to have access to contraceptives, there must be included within that cluster the right to submit to a medical procedure that may bring about, rather than prevent, pregnancy.¹⁵

Others take a narrower view of the Supreme Court's decisions about reproductive liberty. In this view, the Court merely aimed to protect bodily integrity from direct interference by the state (which would occur if the state compelled or prohibited abortions or contraceptive use) and

¹³See, e.g., Griswold v. Connecticut, 381 U.S. 379 (1965); Eisenstadt v. Baird, 405 U.S. 438 (1972). Early decisions protected the married couples' right to privacy to make procreative decisions, but later decisions focused on individuals' rights as well. The U.S. Supreme Court, in Eisenstadt v. Baird, stated, “[i]f the right of privacy means anything, it is the right of the individual, married or single, to be free from unwarranted governmental intrusion into matters so fundamentally affecting a person as the decision whether to bear or beget a child.” Eisenstadt v. Baird, 405 U.S. 438, 453 (1972).

¹⁴Planned Parenthood v. Casey, 505 U.S. 833, 112 S.Ct. 2791, 2810 (1992).

¹⁵Lifchez v. Hartigan, 735 F.Supp. 1361 (N.D. Ill.), aff'd without opinion, sub nom., Scholberg v. Lifchez, 914 F.2d 260 (7th Cir. 1990), cert. denied, 111 S.Ct. 787 (1991).

particularly to ensure that the law not unduly burden women's choices. Thus interpreted, the Constitution would not guarantee individuals unfettered access to assisted reproductive technologies.

Commentators arguing over whether the Constitution should be interpreted to protect the right to create a child through somatic cell nuclear transfer thus begin by debating the present scope of procreative liberty, and then addressing whether or not this method is qualitatively different from existing forms of medically assisted reproduction. Some argue that if the method can be used as a means to serve reproductive ends, it should be classified as procreation. Others disagree, deeming cloning with somatic cell nuclear transfer to represent a radical new step that should be classified as “replication,” rather than “reproduction” (Annas, 1997; Kass, 1997; Macklin, 1997; Robertson, 1997).

To the extent that cloning invokes the choice to generate a child, it is indeed procreative. On the other hand, cases discussing procreative rights have always been premised on underlying assumptions about the meaning of procreation, for example, that it is interdependent, involving the reproductive cooperation of a male and a female, at least on the biological level. Another assumption has been that it involves the transmission of genes vertically across a generation, that is, between a parent and child. Cloning via somatic cell nuclear transfer represents a form of genetic duplication within an existing generation.

Whether cloning is best characterized as procreation or as something entirely new and different is a matter of debate, for which existing decisions by the U.S. Supreme Court offer only partial guidance. Thus, it is impossible to say with certainty whether somatic cell nuclear transfer cloning would be treated in law as a fundamental right. But if it were to be treated as a fundamental right, then arguments against the practice based on speculative psychological and social harms would be tested against the strictest scrutiny of the judicial system.

Policy Options

It is against this backdrop that the Commission developed the following policy options:

- To continue the existing moratorium on federal funding of any effort to create a child through somatic cell nuclear transfer, and to emphasize that the intent of this moratorium is to cover any effort to use federal funds for this technology whether in a clinical or research setting.
- To obtain the agreement of the private sector to abide by the spirit of the federal moratorium.
- To extend to all participants in research protocols the human subjects protections already in place for those enrolled in federally funded protocols.

- To prohibit efforts to clone human beings by federal statute.
- To facilitate public education and debate, in preparation for legislative action, if any, and to carry on a national discussion about the uses of somatic cell nuclear transfer cloning technology.
- To cooperate with other nations to enforce any common elements of our respective policies regarding efforts to clone human beings.

OPTION: Continue the Moratorium on the Use of Federal Funding for the Creation of a Child Using Somatic Cell Nuclear Transfer

The first, and simplest, of the policy options is to call for a continuation and expansion of the March 4 Presidential ban on the use of federal funds for cloning of human beings via somatic cell nuclear transfer. The continuation of this moratorium could encompass both federal research funds, such as those made available by the Department of Health and Human Services, as well as other federal payments. Thus, for example, Medicaid and Medicare could make clear what is already widely assumed, to wit, that they will not pay for any efforts to attempt to create a child via somatic cell nuclear transfer because, among other things, they do not pay for experimental procedures.¹⁶

It may be worth exploring, as well, the feasibility of attaching conditions to the receipt of certain federal funds so as to extend the prohibition on cloning of human beings via nuclear transplantation. For example, the federal government provides large block grants for maternal and child health services. In light of the significant risks to the child's health posed by this technology, it might be appropriate to condition receipt of federal funds on the promise to prohibit attempts within a specific institution. In the past, such an approach has been used with regard to prospects for human gene therapy. Thus, in the 1980s, institutions were told that they could receive federal funds for work on recombinant DNA therapy on the condition that no one would attempt to use it in people until the specific application had been reviewed for its safety and ethical acceptability by a specially created review body. Compliance with these conditions has been excellent.

OPTION: Appeal to the Private Sector for Adherence to the Intent of the Federal Moratorium on the Cloning of Human Beings

An appeal can be made immediately to all portions of the private sector, and to all relevant societies of clinicians and researchers, urging them to forego any attempt to use nuclear transfer to

¹⁶The applicability of Medicare (which generally pays for the care of persons aged 65 or older) may not be apparent, but with the advent of post-menopausal pregnancy via hormonal maintenance, Medicare unexpectedly became a public insurer with at least theoretical obligations to pay for pregnancy care. Furthermore, even if the female partner is not covered by Medicare, the male partner, from whom the somatic cell nucleus might be obtained, could be old enough to be a Medicare beneficiary.

create a child. Compliance could well be high, especially within the research community, which has a history of successfully invoking voluntary moratoria even on exciting and appealing innovations such as gene therapy. In another notable instance, scientists voluntarily suspended certain experiments using recombinant DNA technology in the 1970s, so that safety standards might be debated.

The closest analogy to a moratorium on cloning human beings may well be found in the existing moratorium on the use of germ line gene therapy, i.e., deliberate changes in human DNA intended to be inherited. A decade ago, the consensus was that no one could do gene therapy safely and reliably. Opinion split about the prudence of banning it. On the one hand, there seemed little harm in banning it, with some prospect of public assurance as a benefit. On the other hand, if the technology evolved sufficiently, one might imagine clinical scenarios, however rare, where it could be useful.

Policy on deliberate germ-line intervention now varies from barely permissive to explicitly proscriptive. In the United States, the Recombinant DNA Advisory Committee of the National Institutes of Health [RAC] “will not *at present* entertain proposals for germ line alterations” [emphasis added]. This turn of phrase conveys that the RAC is not prepared to approve such experiments now, but it invites researchers to submit protocols that might offer an acceptable risk/benefit balance. This was a deliberate decision, as an outright ban was urged by the Council for Responsible Genetics (CRG) in 1985, but the RAC elected to stay with its language. German and Danish laws, by contrast, say that such germ-line intervention is a criminal act. Thus, for ten years, RAC has had a *de facto* ban on germ line gene therapy. If a concrete, clinically defensible proposal is ever made, RAC can simply choose to review the protocol if need be (Cook-Deegan 1997).

Many scientific societies have already indicated to NBAC their support for a moratorium on efforts to use somatic cell nuclear transfer cloning to create a child. Of thirty-two societies contacted, the majority stated that they take the position that it is wrong at this time to attempt to clone human beings.¹⁷ The World Medical Association, representing clinicians around the world, has also endorsed a moratorium.¹⁸ Historically, moratoria have garnered less resistance than governmentally imposed prohibitions. In addition, such moratoria avoid governmental intrusion into the freedom of scientific inquiry via legislative fiat. Finally, and perhaps counter-intuitively, a self-imposed moratorium may be more durable, as it is largely immune from constitutional

¹⁷To receive input on scientific and professional society views about cloning of human beings, NBAC commissioned the Critical Technologies Institute of RAND to request informal input from relevant organizations, of which 32 responded. “Views of Scientific Societies and Professional Associations on Human Nuclear Transfer Cloning Research,” by Elisa Eiseman, May 1997.

¹⁸“Global Group Urges a Voluntary Ban on Human Cloning,” *Chicago Tribune*, May 12, 1997, p. 16.

challenges, which are more often successful when individuals challenge governmental—as opposed to private—limitations on personal choices.

On the other hand, a voluntary moratorium may not be sufficient to deter the occasional use of somatic cell nuclear transfer cloning. No one has offered NBAC a good estimate of the number of laboratories that might be capable of attempting to use somatic cell nuclear transfer to create a child, but W. Bruce Currie, a biologist at Cornell University, estimates that at least ten fertility clinics in the United States have the technology (Begley 1997). The history of infertility treatment—especially that of *in vitro* fertilization—demonstrates that where there is a sizeable and well financed demand for a novel service, there will be professionals willing to try to provide it. Indeed, the professional societies in the infertility field have not joined the A.M.A. in its statement that efforts to use somatic cell nuclear transfer cloning to create a child are unacceptable at this time. Further, sanctions against those who try to provide the service prematurely are weak. State medical licensing authorities, for example, are not as vigorous in their prosecution of medical violations as they could be (Grad & Marti 1979; Hogan 1983).

As mentioned previously, if somatic cell nuclear transfer cloning were attempted, the only federal legislation clearly on point would be the Fertility Clinic Success Rate and Certification Act of 1992 which regulates assisted reproductive technology programs. But despite this and arguably applicable state statutes, there is no comprehensive protection at the federal or state legislative levels against dangerous applications of technology that could be used to try to clone a human being in this manner.

The threat of medical malpractice litigation might provide some protection against premature application of a risky technology, but it too is lacking. Since the very people who request the service most urgently are the ones who would hold the privilege of suing for malpractice, it is unlikely that many suits would be brought, even if the technology were to prove tragically flawed for human application. And even though the child himself or herself would hold an independent right to sue for injuries incurred through premature use of the technique, the limited range of legal actions, and the need for someone other than the parents to be motivated to obtain authority to sue on the child's behalf, makes this, too, an inadequate means of policing the clinical application of the technology.

Nonetheless, in order to bolster the effectiveness of a self-imposed moratorium on cloning human beings, state authorities should be called on to tell their licensed practitioners that this technology is not ripe for human application. Relevant clinical societies should be urged to do the same. Professional societies can set voluntary, informal standards for professional behavior, require members to participate in continuing professional education to maintain active membership status, or require periodic examination. They can have codes of ethics governing general behavior, as do the American Medical Association and the National Society of Genetic Counselors. A professional organization can also survey its members and gather data on new techniques.

On the other hand, membership in professional societies is voluntary, as is members' adherence to an organization's code of conduct and standards. Moreover, not every relevant professional organization has publicly expressed its opposition to such cloning attempts.

Still, it is notable that the American Medical Association has already stated to NBAC that it is not an acceptable form of medical practice to attempt to clone human beings through somatic cell nuclear transfer; the World Medical Association and the World Health Organization have issued similar statements. The result should be to deter efforts to use the technology, and to make redress against those who do use it somewhat easier, should malpractice suits be filed. Not only do such statements provide guidance to practitioners directly, they also provide guidance to courts, which have increasingly become arbiters of whether a health care provider has met his or her professional obligations to a patient.

OPTION: Legislate Extended Human Subjects Protections

A third action that could be taken to prevent dangerous uses of cloning would be to extend existing human subjects protections to all persons in the United States. At the moment, these protections extend only to those persons enrolled in research trials at institutions that have executed a multiple project assurance with the government; those in trials using Food and Drug Administration (FDA)-regulated investigational drugs, devices, and biologics; and those enrolled in trials sponsored by one of the 17 federal agencies that have adopted the common rule for subject protection. This still leaves some number of research subjects unprotected by federal law, as documented by the NIH Office for Protection from Research Risks in its presentation to NBAC at the first commission meeting, and, more recently, in an April 10, 1997 letter to the NBAC subcommittee on human subjects protections.

By extending protection to encompass all research settings, any researcher attempting to use nuclear transfer cloning to produce a human child within the context of a “systematic investigation” (which is the federal definition of research) would be subject to Institutional Review Board (IRB) review of the risks, the benefits, the adequacy of the consent, and the justice of human subject selection. In light of the significant physical harms that are expected based on current data, such research could not easily be approved until some compelling benefits have been shown.

An advantage to legislatively extending human subjects protection rather than relying solely on prohibitory legislation or a voluntary ban on cloning human beings is flexibility over time, should information from studies in other animals indicate that physical risks to humans are less than expected. More importantly, this approach represents a robust response to new and unanticipated technological innovations. Rather than addressing cloning alone, it sets the stage for review of any new technology that has application in humans, by taking full advantage of the existing system of decentralized IRB review. In addition, it accomplishes other NBAC goals regarding the extension of basic human subjects protections.

This particular legislative option does, however, suffer from several disadvantages. First, because it requires legislative action, it cannot be implemented immediately. Further, it depends on the decentralized IRB review system, which itself has been subject to much criticism as inadequate to the task, due to overwork, conflicts of interest, and the absence of sufficient expertise, particularly with regard to novel technologies.¹⁹ Finally, because the protections it offers extend only to those enrolled in research protocols, it does not address experimental use of this technology that is offered in a therapeutic or other non-research guise; for that setting, e.g., a stand-alone infertility clinic, the protections outlined above regarding voluntary moratoria and professional society or disciplinary body statements must be used, or a legislative prohibition must be adopted.

OPTION: Legislative Ban on the Use of Somatic Cell Nuclear Transfer to Create a Child

If the foregoing options do not suffice to deter dangerous or premature efforts at cloning, or if the more general societal harms are viewed as sufficiently alarming as to require more dramatic attention, then a legislative prohibition may be needed. Indeed, such prohibitions are already being considered by a number of state legislatures and will probably be adopted by a number of other countries or international bodies as well (Knoppers, 1997).

The advantage to federal legislation—as opposed to state-by-state laws—lies primarily in its comprehensive coverage and clarity, as it would cover both private and public work in both research and clinical settings. Besides ensuring interstate uniformity, a federal law would relieve the need to rely on the cooperation of diverse medical and scientific societies, or the actions of diverse IRBs, to achieve the policy objective. As an additional benefit, federal legislation could displace the varied state legislative efforts now ongoing, some of which suffer from ambiguous drafting that could inadvertently prohibit the important cellular and molecular cloning research describe in Chapter Two of this report. Further, by unifying law at the national level, federal legislation could prevent “forum shopping,” in which researchers or clinicians are enticed to relocate to states where protections against dangerous uses of cloning are fewer.

In addition, legislative prohibitions offer the opportunity to draft significant penalties for violation, thus increasing the deterrent effect enormously as compared to that offered by the other measures outlined above. Indeed, one of the strongest deterrent effects might be to inhibit incipient commercial interest in the use of the technology for infertility relief, thus removing a structural force that could otherwise lead to intense and possibly premature pressure to attempt clinical application before necessary research in animals has been completed.

Finally, a clear prohibition on efforts to create a child through nuclear transfer could help to quell anxieties with regard to the purely molecular and cellular techniques, also called “cloning,” that form the basis of much of contemporary biomedical science, and that continue to hold such

¹⁹See transcripts of NBAC Human Subjects Subcommittee meeting, December 16, 1996.

promise for medical and scientific advance without raising the same ethical issues as those associated with creating a child.

On the other hand, there are some drawbacks to federal legislation. There is a tradition in the United States of foregoing federal legislation in areas traditionally reserved to the states. Direct regulation of family affairs and of medical practice—both of which would be implicated in a legislative prohibition—represents two such areas. Thus, federal action could stifle the diverse policy responses of the states, should some states wish to be more liberal in permitting nuclear transfer to create a child. It would also hinder experimentation with different legal regimes governing the technology, perhaps obscuring lessons that might be learned from long term observation of the experiences in states with diverse legislative responses to this technique.

A legislative ban also would represent a strong obstacle to changes in policy as scientific information develops. While it is true that a ban could always be removed by a vote to repeal the prohibition, such an effort would take a strong interest group lobbying for change. Since the applications of cloning for procreation are likely to be few, and the numbers of persons with a strong interest in pursuing this option similarly small, a legislative ban might leave some small number of persons with compelling needs nonetheless unable to pursue their interests.

It is for this reason that one should consider a legislative ban that includes a sunset provision. It is notoriously difficult to draft legislation at any particular moment that can serve to both exploit and govern the rapid and unpredictable advances of science. Some mechanism, therefore, such as a sunset provision, is absolutely needed to ensure an opportunity to re-examine any judgement made today about the implications of somatic cell nuclear transfer cloning of human beings. As scientific information accumulates and public discussion continues, a new judgment may develop and we, as a society, need to retain the flexibility to adjust our course in this manner. A sunset provision would dictate that the prohibition expire, either automatically after a certain period of years, or upon recommendation by some sort of review body set up for this purpose. While the inclusion of a sunset provision risks losing some of the public confidence gained by a legislative prohibition, it ensures that the question of cloning will be revisited by the legislature in the future, when scientific and medical questions have been clarified, possible uses have been identified, and public discussion of the deeper moral concerns about this practice has matured.

A sunset provision, however, would have to include details explaining how and when the legislative ban would expire. One alternative is simply choosing an arbitrary number of years, which may or may not coincide, of course, with that moment at which significant new information about the technology has emerged and/or when new moral agreements on these issues are achieved. Another alternative is the creation of a body charged with identifying the moment, if ever, when the ban ought to be repealed. A third alternative is to combine these approaches and create a body that would report at a specific time on whether the legislative prohibition should be continued. The details of who should set up such a body, how its members should be appointed, the criteria by which it would render its decisions, and the tasks it should undertake in order to monitor the technology are crucial for the design of this sort of sunset provision. One advantage

to the creation of such a body, however, is its availability to serve as a forum for ongoing public education about the technology, as it develops, in order to deepen and widen the discussions about the ethics of its use.

OPTION: Cooperate With Other Nations in the Enforcement of Common Elements of Our Policies Regarding Human Cloning

Since science and medicine are now transnational endeavors, the U.S. government could look for ways to cooperate with other nations and international bodies to enforce any common policies aimed at deterring efforts to clone a human being. These could include agreement to enforce one another's prohibitory legislation where appropriate, as well as for the United States to affirm its commitment to some of the international documents being prepared. Indeed, plans for such prohibitions have already been announced by Germany and France,²⁰ and the United Kingdom is examining its own existing law to ensure that efforts to clone a human being would be clearly prohibited. European opinion seems unanimous on this point, and 20 countries associated with the Council of Europe have called for such a ban,²¹ an idea endorsed by the World Health Organization.²²

In addition, two international ethics committees, one governmental (UNESCO), and the other a committee of the non-governmental Human Genome Organization (HUGO) have been created for the study of the ethical, legal and social issues surrounding human genetics. Neither has an explicit statement on cloning, but the UNESCO International Bioethics Committee has as its mandate, "the preparation of an international instrument on the protection of the human genome" (1993).

The preamble of UNESCO's proposed *Universal Declaration on the Human Genome and the Protection of Human Rights* recalls the universal principles of human rights as found in the international instruments and recognizes that: "research on the human genome and the resulting applications open up vast prospects for progress in improving the health of individuals and of humankind as a whole, but emphasiz[es] that such research should fully respect human dignity and individual rights . . . "

The International Ethics Committee of HUGO in its *Statement on the Principled Conduct of Genetic Research* was also concerned with research under the Human Genome Project and Human Genome Diversity Project generally, and not with any particular form of research.

²⁰Emma Thompson, "Germans and French Press for Worldwide Ban on Human Cloning," *The Herald* (Glasgow), April 30, 1997, p. 14.

²¹Gile Tremlett, "Twenty European Countries Sign International Convention," *The Times* (U.K.), April 5, 1997.

²²"Health Agency Says Cloning of Humans Unacceptable," *Chicago Tribune*, May 15, 1997.

However, the *Statement* in its background principles refers to the "acceptance and upholding of human dignity and freedom."

While easily dismissed as too broad and vague, these international approaches, which are necessarily the result of compromise, may prove to be more inclusive than the narrow, scientific definitions often found under national legislation. To the extent that cloning human beings via somatic cell nuclear transfer is viewed by these nations and international organizations as incompatible with human dignity, prohibitions under domestic law of the signatory countries will follow, either by legislative initiative, as mentioned above, or by interpretation of existing laws and policies.

For example, in December 1996, the renowned biologist Dr. Anne McLaren of the United Kingdom stated in her report on "Research on Embryos in Vitro: The Various Types of Research" that "[a]reas of research that are widely regarded as ethically unacceptable and often prohibited by law include the following: . . . 3) cloning by nuclear substitution." (Convention, 1996). At the same meeting, the Spanish expert J. Egozcue stated in his report on "Research in Human Conceptuses" that "[o]ther lines of research are forbidden or even penalized, although in some cases they may correspond to extremely useful models for the study of some special situations, that do not carry with them any danger, menace or unethical load. Among them are cloning, parthenogenesis, the production of chimeras, interspecies fertilization (with the exemption of the human-hamster system), any modification of the genome (or of the non-pathological genome, as in the Spanish law) and germ-cell therapy."

Nations as diverse as Argentina, China, and Japan have indicated an intention to deter efforts to clone human beings using somatic cell nuclear transfer. When joined with their European counterparts, these nations represent a global trend to avoid reproductive applications of this technology.

Table 1: Proposed Legislation Pertaining to Cloning Human Beings

Federal	
.	S. 368, a bill to ban the use of federal funds for research with respect to the cloning of a human individual, defined as “the replication of a human individual by the taking of a cell with genetic material and the cultivation of the cell through the egg, embryo, fetal, and newborn stages into a new human individual.”
.	H.R. 922, providing that “[n]one of the funds made available in any Federal law may be expended to conduct or support any project of research that involves the use of a human somatic cell for the process of producing a human clone.”
.	H.R. 923, providing that “it shall be unlawful for any human person to use a human somatic cell for the process of producing a human clone.”
State	
Bills that	
.	ban the use of governmental funds for any research using cloned cells or tissue Alabama [A.B. 1082 (introduced April 23, 1997)]
.	ban the use of governmental funds for cloning an entire individual Missouri [1997 Mo. H.B. 824 (introduced March 6, 1997)] Maryland [Md. H.J.R. 28 (introduced March 20, 1997)]
.	ban cloning an entire individual, regardless of funding source Alabama [S.B. 511 (introduced March 7, 1997)] California [Cal. S.B. 1344 (introduced March 11, 1997)] Illinois [1997 Ill. H.B. 2235 § 5 (introduced March 10, 1997)] Illinois [1997 Ill. S.B. 1829 (introduced March 7, 1997)] New Jersey [N.J.A.B. 2849 § 1 (introduced March 24, 1997)] New York [1997 S.B. 2877 (introduced February 26, 1997)] North Carolina [S.B. 782 (introduced April 10, 1997)] Oregon [Ore. S.B. 1017 § 1 (introduced March 19, 1997)] West Virginia [W. Va. S.B. 410 (introduced March 21, 1997)]
.	explicitly ban any research using cloned cells or tissue California [A.B. 1251 (introduced February 28, 1997)] Florida [Fla. H.B. 1237 (introduced March 7, 1997)]
.	might unintentionally ban research using cloned tissue or cells South Carolina [H.B. 3617 § 16-17-745(B) (introduced March 11, 1997)] New York [Assembly Bill 5383 (introduced March 4, 1997)]

References

- Andrews, L., "The Current and Future Legal Status of Cloning," paper commissioned by the National Bioethics Advisory Commission, April 1997.
- Annas, G., Testimony before the Subcommittee on Public Health and Safety, of the Senate Labor and Human Resources Committee, March 12, 1997.
- Begley, S., "Little Lamb, Who Made Thee?" *Newsweek*, March 10, 1997, pp. 53-57.
- Brock, D., "Public moral discourse," in *Society's Choices: Social and Ethical Decision Making in Biomedicine*, Ruth Bulger, Elizabeth Bobby, Harvey Feinberg, (eds.)(Washington, D.C.: National Academy Press, 1995).
- Cook-Deegan, R.M., "Do Research Moratoria Work?" paper commissioned by the National Bioethics Advisory Commission, April 1997.
- Eiseman, E., "Views of scientific societies and professional associations on human nuclear transfer cloning research," paper commissioned by the National Bioethics Advisory Commission, May 1977.
- Glendon, M.A., *Rights Talk* (New York: The Free Press, 1991).
- Hogan, G., "The effectiveness of licensing: History, evidence, and recommendations," 7 *Law and Human Behavior* 117 (1983).
- Grad, F., and N. Marti, *Physician Licensure and Discipline: the Legal and Professional Regulation of Medical Practice* (New York: Matthew Bender, 1979).
- Kass, L., Testimony before the National Bioethics Advisory Commission, March 14, 1997.
- Knoppers, B., "Cloning: An International Comparative Perspective," paper commissioned by the National Bioethics Advisory Commission, April 1997.
- Macklin, R. Testimony before the National Bioethics Advisory Commission, March 14, 1997.
- Nagel, T., "Moral Epistemology," in *Society's Choices: Social and Ethical Decision Making in Biomedicine*, Ruth Bulger, Elizabeth Bobby, Harvey Feinberg, (eds.)(Washington, D.C.: National Academy Press, 1995).
- Robertson, J., Testimony before the National Bioethics Advisory Commission, March 14, 1997.

Chapter Six

RECOMMENDATIONS OF THE COMMISSION

With the announcement that an apparently quite normal sheep had been born in Scotland as a result of somatic cell nuclear transfer cloning came the realization that, as a society, we must yet again collectively decide whether and how to use what appeared to be a dramatic new technological power. The promise and the peril of this scientific advance was noted immediately around the world, but the prospects of creating human beings through this technique mainly elicited widespread resistance and/or concern. Despite this reaction, the scientific significance of the accomplishment, in terms of improved understanding of cell development and cell differentiation, should not be lost. The challenge to public policy is to support the myriad beneficial applications of this new technology, while simultaneously guarding against its more questionable uses.

Much of the negative reaction to the potential application of such cloning in humans can be attributed to fears about harms to the children who may result, particularly psychological harms associated with a possibly diminished sense of individuality and personal autonomy. Others express concern about a degradation in the quality of parenting and family life. And virtually all people agree that the current risks of physical harm to children associated with somatic cell nuclear transplantation cloning justify a prohibition at this time on such experimentation.

In addition to concerns about specific harms to children, people have frequently expressed fears that a widespread practice of somatic cell nuclear transfer cloning would undermine important social values by opening the door to a form of eugenics or by tempting some to manipulate others as if they were objects instead of persons. Arrayed against these concerns are other important social values, such as protecting personal choice, particularly in matters pertaining to procreation and child rearing, maintaining privacy and the freedom of scientific inquiry, and encouraging the possible development of new biomedical breakthroughs.

As somatic cell nuclear transfer cloning could represent a means of human reproduction for some people, limitations on that choice must be made only when the societal benefits of prohibition clearly outweigh the value of maintaining the private nature of such highly personal decisions. Especially in light of some arguably compelling cases for attempting to clone a human being using somatic cell nuclear transfer, the ethics of policy making must strike a balance between the values society wishes to reflect and issues of privacy and the freedom of individual choice.

To arrive at its recommendations concerning the use of somatic cell nuclear transfer techniques, NBAC also examined long-standing religious traditions that often influence and guide citizens' responses to new technologies. Religious positions on human cloning are pluralistic in their premises, modes of argument, and conclusions. Nevertheless, several major themes are prominent in Jewish, Roman Catholic, Protestant, and Islamic positions, including responsible human dominion over nature, human dignity and destiny, procreation, and family life. Some

religious thinkers argue that the use of somatic cell nuclear transfer cloning to create a child would be intrinsically immoral and thus could never be morally justified; they usually propose a ban on such human cloning. Other religious thinkers contend that human cloning to create a child could be morally justified under some circumstances but hold that it should be strictly regulated in order to prevent abuses.

The public policies recommended with respect to the creation of a child using somatic cell nuclear transfer reflect the Commission's best judgments about both the ethics of attempting such an experiment and its view of traditions regarding limitations on individual actions in the name of the common good. At present, the use of this technique to create a child would be a premature experiment that exposes the developing child to unacceptable risks. This in itself might be sufficient to justify a prohibition on cloning human beings at this time, even if such efforts were to be characterized as the exercise of a fundamental right to attempt to procreate. More speculative psychological harms to the child, and effects on the moral, religious, and cultural values of society may be enough to justify continued prohibitions in the future, but more time is needed for discussion and evaluation of these concerns.

Beyond the issue of the safety of the procedure, however, NBAC found that concerns relating to the potential psychological harms to children and effects on the moral, religious, and cultural values of society merited further reflection and deliberation. Whether upon such further deliberation our nation will conclude that the use of cloning techniques to create children should be allowed or permanently banned is, for the moment, an open question. Time is an ally in this regard, allowing for the accrual of further data from animal experimentation, enabling an assessment of the prospective safety and efficacy of the procedure in humans, as well as granting a period of fuller national debate on ethical and social concerns. The Commission therefore concluded that there should be imposed a period of time in which no attempt is made to create a child using somatic cell nuclear transfer.

Within this overall framework the Commission came to the following conclusions and recommendations:

I. The Commission concludes that at this time it is morally unacceptable for anyone in the public or private sector, whether in a research or clinical setting, to attempt to create a child using somatic cell nuclear transfer cloning. The Commission reached a consensus on this point because current scientific information indicates that this technique is not safe to use in humans at this time. Indeed, the Commission believes it would violate important ethical obligations were clinicians or researchers to attempt to create a child using these particular technologies, which are likely to involve unacceptable risks to the fetus and/or potential child. Moreover, in addition to safety concerns, many other serious ethical concerns have been identified, which require much more widespread and careful public deliberation before this technology may be used.

The Commission, therefore, recommends the following for immediate action:

- A continuation of the current moratorium on the use of federal funding in support of any attempt to create a child by somatic cell nuclear transfer.
- An immediate request to all firms, clinicians, investigators, and professional societies in the private and non-federally funded sectors to comply voluntarily with the intent of the federal moratorium. Professional and scientific societies should make clear that any attempt to create a child by somatic cell nuclear transfer and implantation into a woman's body would at this time be an irresponsible, unethical, and unprofessional act.

II. The Commission further recommends that:

- Federal legislation should be enacted to prohibit anyone from attempting, whether in a research or clinical setting, to create a child through somatic cell nuclear transfer cloning. It is critical, however, that such legislation include a sunset clause to ensure that Congress will review the issue after a specified time period (three to five years) in order to decide whether the prohibition continues to be needed. If state legislation is enacted, it should also contain such a sunset provision. Any such legislation or associated regulation also ought to require that at some point prior to the expiration of the sunset period, an appropriate oversight body will evaluate and report on the current status of somatic cell nuclear transfer technology and on the ethical and social issues that its potential use to create human beings would raise in light of public understandings at that time.

III. The Commission also concludes that:

- Any regulatory or legislative actions undertaken to effect the foregoing prohibition on creating a child by somatic cell nuclear transfer should be carefully written so as not to interfere with other important areas of scientific research. In particular, no new regulations are required regarding the cloning of human DNA sequences and cell lines, since neither activity raises the scientific and ethical issues that arise from the attempt to create children through somatic cell nuclear transfer, and these fields of research have already provided important scientific and biomedical advances. Likewise, research on cloning animals by somatic cell nuclear transfer does not raise the issues implicated in attempting to use this technique for human cloning, and its continuation should only be subject to existing regulations regarding the humane use of animals and review by institution-based animal protection committees.
- If a legislative ban is not enacted, or if a legislative ban is ever lifted, clinical use of somatic cell nuclear transfer techniques to create a child should be preceded by research trials that are governed by the twin protections of independent review and informed consent, consistent with existing norms of human subjects protection.
- The United States Government should cooperate with other nations and international organizations to enforce any common aspects of their respective policies on the cloning of human beings.

IV. The Commission also concludes that different ethical and religious perspectives and traditions are divided on many of the important moral issues that surround any attempt to create a child using somatic cell nuclear transfer techniques. Therefore, the Commission recommends that:

- The federal government, and all interested and concerned parties, encourage widespread and continuing deliberation on these issues in order to further our understanding of the ethical and social implications of this technology and to enable society to produce appropriate long-term policies regarding this technology should the time come when present concerns about safety have been addressed.

V. Finally, because scientific knowledge is essential for all citizens to participate in a full and informed fashion in the governance of our complex society, the Commission recommends that:

- Federal departments and agencies concerned with science should cooperate in seeking out and supporting opportunities to provide information and education to the public in the area of genetics, and on other developments in the biomedical sciences, especially where these affect important cultural practices, values, and beliefs.

APPENDIX A: GLOSSARY¹

Blastocyst: the developing preimplantation embryo, beginning about 4 days after fertilization. The blastocyst consists of a sphere of cells made up of an outer layer of support cells, a fluid-filled cavity, and a cluster of cells on the interior (the inner cell mass, ICM).

Blastomere: each of the cells produced when the fertilized egg cleaves into 2, then 4, 8, and 16 cells.

Blastomere separation: a technique by which a jelly-like substance is removed from around a two-to eight-cell embryo, or morula, and the embryo is incubated in a special solution so that the blastomeres separate and fall apart. The blastomeres are then cultured separately.

Cellular cloning: the process by which cells derived from the soma, or body, and are grown in tissue culture in a laboratory. The genetic makeup of the resulting cloned cells, or cell line, is identical to that of the original cell.

Chromosomes: nucleic acid-protein structures in the nucleus of a cell. Chromosomes are composed chiefly of DNA, the carrier of hereditary information. Chromosomes contain genes, working subunits of DNA that carry the genetic code for specific proteins, interspersed with large amounts of DNA of unknown function. A normal human somatic cell contains 46 chromosomes; a normal human germ cell contains 23 chromosomes.

Clone: A precise copy of a molecule, cell, or individual plant or animal.

Cytoplasm: the contents of a cell other than the nucleus. Cytoplasm consists of a fluid containing numerous structures that carry out essential cell functions.

Differentiation: the process whereby an unspecialized early embryonic cell acquires the features of a specialized cell such as a heart, liver, or muscle cell.

Diploid: a cell such as a somatic cell having two chromosome sets, as opposed to the haploid situation of eggs and sperm which have only one chromosome set.

¹Many of the definitions were excerpted from the National Institutes of Health *Report of The Human Embryo Research Panel* (Washington, DC: U.S. Government Printing Office, 1994).

DNA: Deoxyribonucleic acid, found primarily in the nucleus of cells (some DNA is also found in the mitochondrion). DNA carries the instructions for making all the structures and materials the body needs to function.

Egg: the mature female germ cell; also called ovum, or oocyte.

Embryo: the developing organism from the time of fertilization until significant differentiation has occurred, when the organism becomes known as a fetus.

Embryo transfer: the introduction of a preimplantation embryo into the uterus for growth and development.

Embryonic stem (ES) cells: primitive undifferentiated cells from the embryo that have the potential to give rise to a wide variety of specialized cell types.

Enucleated egg: an egg from which the nucleus has been removed.

Fertilization: the process whereby male and female gametes unite; it begins when a sperm contacts the outside of the egg and ends with the formation of the zygote.

Gamete: a mature sperm or egg cell.

Gene: a working subunit of DNA. Each of the body's 100,000 genes carries the instructions that allow the cell to make one specific product such as a protein.

Gene targeting: Generating a precise replacement of one gene for a different or altered gene.

Genome: the complete genetic makeup of a cell or organism.

Genetic imprinting: a process that determines, for specific genes, which one of the pair of genes, the mother's or the father's, will be active in a given individual.

Germ cell: a sperm or egg (all other body cells are known as somatic cells).

Inner cell mass (ICM): the cluster of cells inside the blastocyst, which gives rise to the embryo and ultimately the fetus.

In vitro fertilization (IVF): an assisted reproduction technique in which fertilization is accomplished outside the body.

Mitochondrion: A cellular organelle that provides energy to the cell. The mitochondrion contains some of its own genes.

Molecular cloning: the process whereby identical fragments of DNA are produced by insertion of a DNA fragment into a host vector followed by amplification to produce many thousands of copies in a host cell, usually a bacterium.

Mutation: a change in DNA that alters a gene and thus the gene's product, leading in some cases to deformity or disease. Mutations can occur spontaneously during cell division or can be triggered by environmental stresses such as sunlight, radiation, and chemicals.

Nuclear transplantation cloning: a type of cloning in which the nucleus from a diploid cell is fused with an egg from which the nucleus has been removed. The DNA of the transplanted nucleus thus directs the development of the resulting embryo.

Nucleus: the cell structure that houses the chromosomes, and thus the genes.

Oocyte: the mature female germ cell; the egg.

Somatic cells: any cell other than a germ cell.

Sperm: mature male reproductive cells.

Totipotent: having unlimited developmental capacity. The totipotent cells of the very early embryo have the capacity to differentiate into extraembryonic membranes and tissues, the embryo, and all postembryonic tissues and organs.

Zygote: the single-celled, fertilized egg.

APPENDIX B: SPEAKERS

INVITED SPEAKERS

March 13-14, 1997

Lisa Cahill, Ph.D. - Boston College, Department of Theology
Rabbi Elliot Dorff, Ph.D. - University of Judaism, Los Angeles
Nancy Duff, Ph.D. - Princeton Theological Seminary
Leon R. Kass, M.D., Ph.D. - University of Chicago
Ruth Macklin, Ph.D. - Albert Einstein College of Medicine
Gilbert C. Meilaender, Jr., Ph.D. - Valparaiso University
Father Albert S. Moraczewski - National Conference of Catholic Bishops
James L. Nelson, Ph.D. - University of Tennessee
Professor John Robertson, J.D. - University of Texas Law School
Abdulaziz Sachedina, Ph.D. - University of Virginia
Rabbi Moshe Tendler, Ph.D. - Yeshiva University
Shirley Tilghman, Ph.D. - Princeton University

April 13, 1997

Stuart H. Orkin, M.D. - Dana Farber Cancer Institute
Janet Rossant, Ph.D. - Samuel Lunenfeld Research Institute - Mount Sinai Hospital

May 2, 1997

Elisa Eiseman, Ph.D. - Critical Technologies Institute, RAND Corporation

PUBLIC TESTIMONY

March 13-14, 1997

Nancy Reame
Judith Lamb-Lion
Robert Weise
Michelle Theiman
Daniel B. McGee
Gladys White
Claire Nader
John Cavanaugh-O'Keefe
Dan Crow
J. D. Hanson

April 13, 1997

John Cavanaugh-O'Keefe

May 2, 1997

Mary Lyman Jackson
Paulette Roseboro
Sheena Talbot
Lisa Tennant
Audria Williams

May 17, 1997

Gail Youness
John Cavanaugh-O'Keefe

June 7, 1997

Randolfe Wicker
Alan Grayson

APPENDIX C: COMMISSIONED PAPERS

“The Current and Future Legal Status of Cloning” by Lori B. Andrews, J.D., Chicago-Kent College of Law

“Cloning Human Beings: An Assessment of the Ethical Issues Pro and Con” by Dan W. Brock, Ph.D., Brown University

“Religious Perspectives on Human Cloning” by Courtney S. Campbell, Ph.D., Oregon State University

“Do Research Moratoria Work? A Review of Fetal Research, Gene Therapy, and Recombinant DNA Research” by Robert Mullan Cook-Deegan, M.D.

“Views of Scientific Societies and Professional Associations on Human Nuclear Transfer Cloning Research” by Elisa Eiseman, Ph.D., RAND Corporation

“Cloning: An International Comparative Overview” by Bartha Maria Knoppers, J.D., University of Montreal

“Animal Cloning and Related Embryo Research: Implications for Medicine” by Stuart H. Orkin, M.D., Dana Farber Cancer Institute

“The Science of Animal Cloning” by Janet Roussant, Ph.D., Samuel Lunenfeld Research Institute - Mount Sinai Hospital