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Volume 4, Number 1, Fall 2005

TABLE OF CONTENTS

Acknowledgements	4
Introductions:by Dr. John Loike, Professor Robert Pollack and Dr. Ruth Fischbach	5-7
Section I: Stem Cell Research	
A Political Science: Human Embryonic Stem Cells	Afreen Hoque8 Kelly Steele
Patent Faux-Pas Fuel Controversy Over Stem Cell Research	Jessica Midence 12 Azatuhi Ayrikyan
Stem Cells: For Cure or Creation?	Kalle Greven 15 Chris Urband
The Ethics of Empathy: Reconciling the Science and Morality of Stem Cell Research	Cindy Parra 17 Dean Lentzeres
You Don't Own Me... Or Do You?	Alicia Cartwright 20 Kevin Kow Dean
Stem Cell Therapy: The Future of Medicine?	Azatuhi Ayrikyan 23 Jacqueline Kamrath
Section II: Genetic Testing	
Dangers of Preconception Sex Selection	Divya K Shah 27
IVF and Age Limits	Jennifer Laine 33
Mother or Grandmother? Too Old To Reproduce?	Jemma Lampkin 38 Anna Shlionsky
Life's First Test	Tamar Glatt 41 Alice Zhao
Section III: Back to the Future	
Moving Beyond Moral	Othell Begay 43 Neha Jain
A Drink From the Fountain of Youth	Jessica Midence 45 Steven Kunen
The Brain on Trial: Waves of the future	Jackie Kamrath 50 Stephen Kunen
The Frankenstein Phenomenon: Genius or Tunnel Vision?	Sarah Harkness 52 Jessica Stern
Researching the Genetics of Homosexuality:	Sarah Harkness 54 Jessica Stern
Double-Edged Sword of Progress: The Consequences of Regulating Scientific Literature.	Constantine Nicholas Lentzeres 57 Kevin Jianlin Kow
Photographs	Bioethics Class..... 60

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Introduction

In the spring of 2005, the debate on embryonic stem cells took a slightly different pathway. The National Academy of Sciences issues a 131 page document outlining its recommendations for embryonic stem cell research and in particular the use of stem cells to create human animal chimeras. As evident from the many articles in this year's Columbia University Journal of Bioethics, the debate surrounding stem cell research is still in full swing. Our students have presented their opinions on the issues and their views represent the views of our future scientists and physicians.

Topics in Biology: Frontiers in Bioethics is a course that addresses these bioethical dilemmas to Columbia University students interested in pursuing careers in science-based fields. These students will emerge as the front line of scientific discovery. Their future innovative research and ability to communicate science to the public will elicit, or inspire bioethical debate. Furthermore, they will become essential players in helping society resolve bioethical dilemmas.

The main objectives of this course were: to analyze bioethical dilemmas from a scientific perspective, to increase the sensitivity to, and appreciation of bioethical concerns surrounding scientific breakthroughs, and to develop guidelines that either resolve or manage the ethical challenges of scientific discoveries. The authors of these essays are all students at Columbia University, many of whom were enrolled in *Frontiers in Bioethics*. However, all the authors represent aspiring scientists, physicians, lawyers and philosophers whose thoughts and opinions are the heartbeat of this Journal.

I would like to thank the various groups that provided financial assistance to publish this Journal including; The Department of Biological Sciences of Columbia University, The Center For the Study of Science and Religion of Columbia University, The Center for Bioethics of Columbia University, and the Department of External Relations of Columbia University. As the Instructor for *Frontiers in Bioethics*, I appreciate the efforts and energies of all those involved to create this Journal. I am especially indebted to the contributing authors and student editors who put in countless hours to ensure the Journal's success.

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Columbia University College of Physicians & Surgeons
and Center for Bioethics
New York, NY

Introductory letter from Professor Robert Pollack

Lucy Grealy was a young woman of Irish descent whose face was carved up in the treatment of a sarcoma when she was only ten years old. While she had many subsequent operations, all only partially successful, her first one was in a place some of our students already know from their research: Children's Hospital of Columbia Medical Center. In her serious and subtle memoir "Autobiography of a Face," written only a few years before her sad and untimely death, she looks back on her early experience of freedom on Halloween, when she was only one of many masked children, and of her new discovery of her true freedom:

"And then I experienced a moment of freedom I'd been practicing for behind my Halloween mask all those years ago. As a child I had expected my liberation to come from getting a new face to put on, but now I saw it came from shedding something, shedding my image."

What was true for her in a personal sense, is true for all medical science as well. Medical ethics, bioethics, or just plain ethics; it does not matter, all of these are usually lumped together as masks, additional outward appearances unnecessary for the safe progress of real science, which itself has no intrinsic need of any of them. The patient reader who sets aside the young age of our authors will find in this journal the great wisdom of Lucy Grealy brought to life. In this Journal, ethics are not an addition to science. Here, ethics emerge as an intrinsic part of science, as the mask of affectless, emotionless, value-free objectivity is set aside.

We can only hope these students learn from their own examples, and create for us all a better medical science as they attain the positions of leadership that are their due.

Robert Pollack, Ph.D.
Professor of biological Science
Director, Center for the Study of Science and Religion

Preface

The Spring 2005 edition of the Columbia University Journal of Bioethics is an extraordinary publication. Although the articles are authored by students, the wisdom expressed is significant. In their seminal articles, they have examined the ethical, legal, and social questions that arise when scientific findings are carried into medical practice, legal interpretations, as well as health and social policy.

The questions posed here by the authors are at the interface where science confronts ethics. They are the questions that are perplexing both scientists and the public alike: When is it too late to have a child? Does the administration of a brain-fingerprinting test violate the personal privacy of one's own thoughts, that is, would it be just if someone could use your most intimate thoughts and memories against you? Is a cell, with the potential to become a human being, worth more than an already established life? Can a researcher own the rights to a certain form of life? What status do reprogrammed adult cells have, which by nature would not have the potential to develop into a complete organism, but which have gained this potential through human intervention? Do we want to advance our academic superiority and maintain our position as leaders of scientific innovation or should religious sentiment guide economic, scientific, and medical progress even if it may hinder this progress? Should there be restrictions placed on what scientific findings can be published if that information could be used by those with evil and destructive intentions? And most perplexing of all, where do we draw the line between pursuing medical miracles and transgressing immutable moral boundaries? These are crucial bioethical questions that confront us and that must be resolved. Clearly we are in an era where there are breathtaking advances in new and emerging technologies and increasing awareness that along with these advances are the resulting critical implications that must be examined. The articles in this journal encourage us to stretch the limits of our knowledge as well as the boundaries of our imagination. For this, we owe the authors a debt of gratitude.

We should at the same time be assured that the authors of these articles are the thoughtful, concerned, and prepared leaders of tomorrow. I trust that as they pursue their careers, they will uphold the Bioethics mantra: It is not what you can do, rather it is what you should do.

Ruth L. Fischbach, Ph.D., M.P.E.
Professor of Bioethics
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and Mailman School of Public Health

I. Stem Cell Research

A Political Science: Human Embryonic Stem Cells in Short Supply

By Afreen Hoque and Kelly Steele

The 'unregulated' private sector does not function in a political vacuum. The President's current policy on human embryonic stem cell (hESC) research is directly and indirectly usurping financial resources vital to scientific advancement. Science and scarcity do not coexist.

Consider a Tuft's University estimate, bringing the first tablet to market requires an \$800 million to \$1 billion investment (McClellan, 2004). Last year Alzheimer's research cost the National Institute on Aging (NIA) nearly half of its \$994 million congressional grant (Barrett, 2003). Human curiosity, pitted against the diversification of disease, ensures that the only supply cap on the demand for scientific advancement is funding.

The hESC research field violates this assertion, because the political climate in the US generates an infinitely more complicated picture of supply not meeting demand. In a bubble sealed from politics and religion, the medical promise of hESC therapy would skyrocket the demand for more research. The current MVP's of hESC research are: Parkinson's disease, type-1 diabetes, degenerative heart disease, and spinal cord injuries (Weiss, 2004). In Parkinson's experiments at the National Institute of Health (NIH), stem cell transplants have regenerated healthy neurons in rat models (Lim, 2005).

There is an enormous range of potential clinical applications for hESC therapy, and enormous number of people (128 million) who stand to benefit from future research. That figure alone should ensure grant requests for hESC land on top of every NIH reviewer's pile. In addition hESCs have every marketer's dream - celebrity endorsement. The late Christopher Reeve, Michael J. Fox, and

In a bubble sealed from politics and religion, the medical promise of hESC therapy would skyrocket the demand for more research.

Ronald Reagan have become the faces of hESC research.

It will take more than incidence numbers, Hollywood faces, or even a scientific breakthrough of Dolly-magnitude to generate sufficient demand for adequate funding. Two world leaders, The Pope and The President, are crippling research efforts. The monopolizing forces they exert on government and society create shortages that are grossly handicapping work with hESC in the US

and abroad.

Money is the most obvious supply-side shortage. The Bush administration's legislation on hESC research is a funding guideline disguised as a policy statement. With the 2001 lift of the ban on hESC, Tommy Thompson, then Secretary of Health and Human Services, estimated \$100 million in federal grants for the first year of research. Federal funding for hESC research stagnated at \$25 million in 2003, a measly .01% of the NIH's \$27 billion budget ("Fast Facts," 2003).

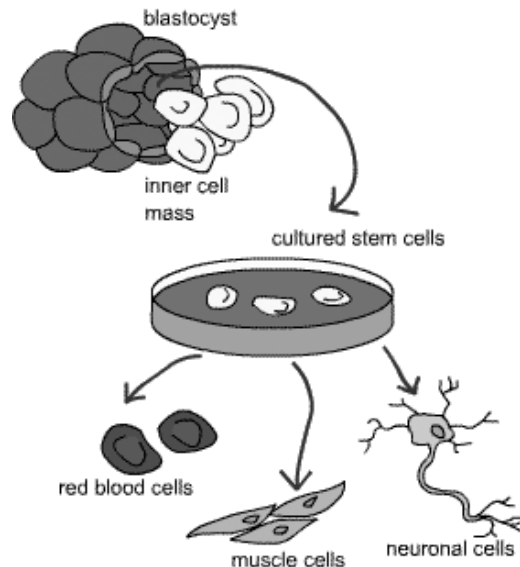
California and New Jersey governments, are planning to invest several billions of dollars of tax revenue in the hESC market. These decisions carry monumental political significance, but fail to compensate for the current dearth in federal funding. The government has chosen to feign disregard for research done outside the NIH umbrella. Policymakers are skirting, not confronting, a bioethical quagmire.

Supporters of Bush's agenda argue that private institutions are successfully carrying the responsibility of funding projects. The reality is that every dollar put towards hESC research carries enormous risk. On August 11, 2001 *The New York Times* reported, "Stocks of companies with even tangential relations to debate over stem cell research are pummeled after President Bush announces support for limited research with federal funding" (Brick, pp. A10).

The wrong political climate could render all hESC projects unconstitutional. Sam Colella, cofounder of Versant Ventures affirms, "Venture capitalists won't commit much until the academic research is done." His opinion is

substantiated by the fact that from May 2003 to November 2004, 14 firms developing stem cell treatments received only \$147.52 million in venture dollars ("Gold Rush," 2004). The assumption that current federal policy stimulates growth in the private sector is dead wrong.

A second monumental scarcity impeding US researchers is cell supply. Currently, only half of the 23 the registered hESC lines are being used in research facilities. These lines were all cultivated on a scaffolding of mouse feeder cells, and are contaminated with viruses



that limit their clinical application. The belief is that cells, when reintroduced to human tissue, will be destroyed by an immune response (Biever, 2004).

Projects totally funded by private funds as those done at the Harvard's Stem Cell Institute are generating cell lines grown on non-biological, alternative scaffoldings. For example, the Harvard Stem Cell Institute announced on March 2004 that they had produced 17 new

embryonic stem cell lines via private funding (Powell, 2004). Legally, federally funded scientists cannot take advantage of stem cells grown on alternative scaffoldings.

As the US continues to work these obsolete stem cell lines, over 400,000 unused embryos lie frozen at fertility clinics. The US is forfeiting to global competition in the industry. France piggybacked Bush's 2001 decree, with the approval of a liberal 5-year law, which allows hESC research to be used for research directly related to the treatment of serious disease. In 2004, the UK ruled that cloning techniques to produce human embryos for stem cells could be used with licenses for medical research ("Diabetics," 2004). On February 12th, 2004 South Korea announced scientists had cloned human stem cells that could be used for cell therapy.

The cruel backlash of US policy is that as other countries outshine US research efforts, supply shortages are amplified. Inevitably, we will witness a brain drain, as top researchers, tired of working with both hands bound, relocate their projects abroad.

In summary, the US hESC research is short on supplies and long on politics. The debate incited by the 1973 Roe vs. Wade ruling is currently masquerading itself in a new guise. Insurmountable abortion issues are dashing hopes for a competitive market for hESC in the United States. The pro-research camp should abandon politics and focus on economics. The most efficient way to redress hampered development is to create alternative markets. Under this plan it is scientists, not politicians, who must take the lead by advancing technologies

that are free from the liabilities of embryo-derived counterparts.

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Patent Faux-Pas Unnecessarily Fuels Controversy Over Stem Cell Research

By Azatuhi Ayrikyan and Jessica Midence

On the top of the laundry list of ethical issues that surround stem cell research is the issue of intellectual property rights, or patent law. It is an issue that could effectively bottleneck research and development in the immediate future. Biological and medical technologies have so many patentable steps up to, and including, the finished product that it is a wonder the public ever benefits from such technologies at a reasonable cost. Stem cell technology is no exception. Researchers can patent the process by which they develop, isolate, and extract pluripotent stem cells. They can also patent the individual cell line that they isolate and modify. In order to make viable stem cells ready to be studied, certain modifications must be made to the cells to make them specific to the study. In other words, researchers do not just make and isolate general pluripotent cells, they make stem cells that are specific to Parkinson's disease or diabetes research, and patent these cell lines.

One can see how the patent policy could be potentially stifling. Currently, less than 64 viable stem cells lines have been identified throughout the world and many of them are patented, effectively blocking any expedient development of stem cell research. It would most certainly behoove the governments of stem cell research savvy counties to consider ways to encourage the use of stem cell research. Hopefully an open research environment would allow stem cell technology to achieve its full potential in our lifetime.

For the past twenty years, biotechnology development has been fueled by the promise of commercialization and monopoly. However, patenting stem cells raises a variety of both ethical and practical concerns. Can a researcher own the rights to a certain form of life? Would patents prevent the availability of a large number of cell lines for the development of therapy?

Therefore, only process patents should be issued for stem cell research, and the issue of patenting individuals or their cells becomes a moot point in the argument against the development of stem cell therapy.

Thankfully, US law already provides some answers to these questions, which, albeit incomplete, should be more than enough to allow the life-saving research that uses stem cells to continue. One of the greatest arguments for the use of embryonic stem cells in therapy has been its incredible potential for treatment of disease. Without the incentive provided by the patent system, both research laboratories and pharmaceutical companies are unlikely to work towards making such treatment accessible. The high costs necessary to bring a drug to market, (nearly 1 billion dollars, according to current estimates) are prohibitive. However, current patent policy

on stem cells only adds fuel to the controversy over their therapeutic use, and requires a great deal of revision.

Current United States patent law requires that an invention satisfy one of four statutory classes of subject matter: machine, process, manufacture, or composition of matter. The last mentioned statutory class (composition of matter) has an even broader definition (if that is possible): "anything under the sun that is made by man." Similar to Canada, the United States has no comprehensive laws that govern stem cell research. The laws that do exist only regulate government-funded research, not private research. However, there are very explicit rules in US patent law preventing the patent of existing life-forms. The fear that allowing stem cell therapy to be patented would result in a patent applications on the genome of John Doe's liver ought to be completely unfounded. The only type of patent that stem cell therapy should be awarded is a process patent, under which the process for treatment of diseases by certain types of stem cells, and the process by which those stem cells are designed, can be patented. However, as was established by *Diamond vs. Chakrabarty*, (Diamond vs. Chakrabarty, 447 US 303; 206 USPQ 193, 1980) the only types of life forms that can be patented are those that have never existed and have no potential to exist in nature. The case on which the precedent is based is the design of a multiplasmid single strain microorganism designed to convert crude oil to protein biomass. This microorganism contained plasmids in combinations that did not and could not occur in nature because the natural organism had only individual plasmids that did not combine in the manner designed by Dr. Chak-

rabarty. Similarly, even if a stem cell is engineered with a particular treatment in mind, the precedent set by the aforementioned case clearly implies that it can not be patented. The purpose of engineering stem cells for therapy is to create healthy human cells. By definition, then, stem cells used in therapy have already occurred in nature and are not patentable.

The question then arises of the creation of "super stem cells" that could differ completely from normal healthy cells, many of which have never existed in nature.



Such speculation should be reserved for science fiction novels. The possibility of developing such stems cells and then using them for therapy is

slim to none. Although such research may be pursued in a laboratory, it is unlikely to receive NIH funding. The NIH is well aware of the limited amount of stem cells available and is unlikely to fund ventures that do not promote the direct treatment of human diseases with the limited stock available. Even if alternate sources for such research are found, it's highly unlikely that the FDA would approve therapy with such stems cells. Therefore, only process patents should be issued for stem cell research, and the issue of patenting individuals or their cells becomes a moot point in the argument against the development of stem cell therapy.

Unfortunately, the patents that have been issued thus far for stem cell research have not abided by the standards set by *Diamond vs. Chakrabarty*, nor have they followed the guidelines established by the US Patent and Trade Office. The derivation and culture of stem cells, patented at the same time by two companies, Geron and WARF, are deserving of a process patent. However, stem cells themselves do not meet the requirement for innovation as required by USPTO policy for the receipt of a patent. Glen McGee, Chair of Bioethics at the University of Pennsylvania, compares this to receiving a patent for gold when the real innovation is on ways to purify it. Stem cells are naturally occurring, and not designed by the researchers who managed to purify and culture them on Petri dishes. Ethical issues aside, the USPTO should not have granted product patents on stem cells to the researchers at Geron and WARF. According to current US law, no one can claim intellectual property rights for a product that has already been created by nature. Had the USPTO followed its own standards, the issue of patenting and commodifying human life would have never even been raised against the development of stem cell therapy.

This is not to say that the scientists researching seminal technologies in the use of stem cells should not be rewarded for their efforts by the patent system. The processes they have developed for the isolation, growth and engineering of stem cells most certainly deserve the patents that have been received. In fact, the patents themselves only claim methodology. However, the interpretation that these developers now have an exclusive monopoly on the stem cells themselves is unfounded and in fact contradictory to US

patent law. This monopoly has not only prevented widespread access to the few available stem cell lines since President Bush's declaration in January of 2004, but has also, illegitimately supported the arguments against stem cell research as a commodification of human life. It is our hope that as the patent controversies between agencies with similar claims are brought to trial, the errors in the interpretation of the law will surface, in order to remove the dark cloud of such controversy from the incredible potential that stem cell therapy has to better the quality of life for Americans.

Stem Cells: For Cure or Creation?

By Kalle Greven and Chris Urband

Imagine that you catch the train for your morning commute and every other passenger looks identical to you. You walk into your office building and everyone there looks just like you as well. This scene is not from the latest Hollywood science-fiction blockbuster. It is a potential result of decisions that are being made today about genetic research. The progress of this research, coupled with the inability of society to agree on how to deal with the new technologies it creates, has set up an environment which may generate undesired consequences.

A young branch of research aims to reprogram adult cells, so that they may be able to regain their embryonic characteristics. The key characteristic is totipotence, which refers to the fact that these cells have the ability to develop into any cell type. Scientists hope that this potential will provide cures to many degenerative diseases. In Parkinson's, Alzheimer's, and Huntington's disease patients, as well as those with spinal cord injuries (think Christopher Reeve), nerve cells deteriorate and cannot be replaced by the body. One company, Advanced Cell Technology (Worcester, MA) has already claimed successes in this field. Led by a scientific advisory board which includes Prof. Keith Campbell, the famed creator of Dolly, this company hopes to develop the technology that will allow a patients' own cells to be converted back to a totipotent state so that they may be used for therapy.

Totipotent cells are a normal part of human development. Soon after fertilization, the cells of the zygote become totipo-

tent. However, most of them lose this characteristic in the further development of the embryo. Since embryonic cells are currently the only completely totipotent cells, they have been required for research. But not for long. According to Advanced Cell Technology, adult cells treated with the reprogramming procedure could be used in the same way as embryonic stem cells. Furthermore, because of their adult origin and since no embryo has to be destroyed, they might be generally accepted by those who oppose embryonic stem cell research. This path would seem to circumvent the ethical questions around the status and the rights of cells gained from early stages of human embryos.

But we may have overlooked a problem. These new cells, like the embryonic cells they mimic, will have the ability to form an entire organism. By the same logic that opposes embryonic stem cell research, won't it then be just as unethical to perform research using these new cells? Shouldn't these reprogrammed adult cells be allowed to reach their potential to become humans? Are we committing the same atrocity by not allowing them to reach this potential? And what status do these cells have, which by nature would not have the potential to develop into a complete organism, but have gained it through human intervention?

Clearly, the argument of status and rights based solely on the potential to develop into a complete individual, is flawed. Every stem cell isolated or extracted would gain the right to develop to an individual, and since all individuals created

from a culture of cells would be identical clones, a potential outcome is the situation depicted above.

If it does not make sense to assign worth based solely on the potential to develop into a complete person, then how *do* we assign worth and inherent rights to totipotent cells?

An adequate definition of rights, worth, and potential might allow us to reduce the suffering and death due to potentially curable diseases, by allowing the use of some cells for research. Unfortunately, the current US policy avoids a new definition, and broadly restricts research in the fields of stem cells, thereby accepting the suffering and death of these people as fate. The March 8, 2005 decision of the UN general assembly to ban any type cloning is the latest example of policymakers oversimplifying the problem.

A trade off needs to be made: Will a cell be used for cure or creation?

Whether we use stem cells derived from embryonic or adult tissue, we will be faced with this question. We should work to solve this problem now so that cures for Parkinson's, Alzheimer's, and Huntington's diseases may be developed sooner, and more people may be saved. The first step will be the creation of an adequate definition of rights, worth, and potential for totipotent cells.



The Ethics of Empathy: Reconciling the Science and Morality of Stem Cell Research

By Dean Lentzeres and Cindy Parra

Is a cell worth more than a human life? Human behavior often conforms to the old adage, "You don't care until it happens to you." For example, you don't wear a seatbelt until your brother gets into a car accident, potato chips are considered a staple in your diet until hypertension rears its ugly head, and funding for Social Security doesn't concern you until it is no longer available when you need it. Most of the advocacy for legislation comes from paid lobbyists who are trained to support a cause that doesn't directly affect them. Public opinion is too often susceptible to mandates and dictums from global, behemoth institutions with their own one-dimensional political motives.

One such topic is the hot-button issue of stem-cell research, which has ruffled the religious right and loosened the tongues of the liberal left to the point of conflagration. Stem cells hold immense promise for the future as they wield the key that could potentially unlock the secret (and expose the vulnerability of) humanity. While the Catholic Church throws the Bible and the phrase, "sanctity of life," at those who contradict their seemingly airtight dogmas, companies like Geron preach their own economically motivated doctrine of "progress." While these two sides duke it out, Alzheimer's is erasing a lifetime of memories. It's time to put aside politics, agendas, and convictions in exchange for a plausible

solution to a very real problem.

The heart of the issue rests on the categorization of life, namely whether a group of undifferentiated cells can be defined as a human life. Stem cells are essentially the blank slates of human cells, and have the ability to differentiate into specialized cells and tissues within the body. Two different types of stem cells exist: embryonic and adult. Embryonic stem cells are defined as pluripotent, capable of differentiating into *any* type of cell, from neurons to nephrons. However, many people object to the fact that they are derived from aborted embryos. The issue of when human life begins is where the conservative and liberal camps diverge. Adult-stem cells, on the other hand, can be directly obtained from the tissues of living individuals, but are not pluripotent. With stem cell technology, diseases such as Parkinson's, diabetes, ALS (Lou Gehrig's), multiple sclerosis, and even Alzheimer's could be eradicated. Stem cell therapy could revitalize deteriorating organs and restore the quality of life for millions of individuals. Despite these benefits, many believe the sacrificing of an embryo is intrinsically immoral.

The ethical issue regarding stem cells is a question of priorities. Is a cell, with the potential to become a human being, worth more than an already established life? Does some cytoplasm and DNA take precedence over someone's dying parent?

What sacrifice might you make to see your own paralyzed child walk again?

Official Vatican doctrine dictates, "No end believed to be good, such as the use of stem cells for the preparation of other differentiated cells, [...] can justify [killing an embryo]". Marianne Mims, of Liberty University vehemently asserts, "Embryonic stem cell research is not beneficial and it will always be unethical... While we must always be sympathetic to those who are suffering, it would be a crime against humanity to

As societal fear of the unknown recedes, history will look upon the prohibition of embryonic stem-cell research as inhumane.

endorse and support an unethical procedure, at the expense of our most defenseless people." The President of the United States sidesteps the issue, saying only that, "Embryonic stem cell research is at the leading edge of a series of moral hazards...I strongly oppose human cloning, as do most Americans. We recoil at the idea of growing human beings for spare body parts, or creating life for our convenience." While the idealism professed in each statement is admirable, each is tinged with the soot of hypocrisy.

While adamant about the preservation of stem cells, Catholic doctrine does not explicitly prohibit the death penalty. Liberty University, a bastion of evangelical conservatism, refuses to even acknowledge the tangible benefits of this new technology. Even the

US President, perpetually preaching from his self-aggrandizing moral pedestal, has shown an unsteady opinion. He wasn't nearly as concerned with the sanctity of life when he waged war against Iraq, as he is during his talks on stem cell research. Obviously those religious and religiously influenced governmental institutions need to reexamine their moral and ethical priorities.

The United Nations General Assembly recently passed a resolution banning all types of cloning, which equates to barring scientists from deriving embryonic stem cells for therapeutic purposes. However, "rogue" nations are thumbing their noses in the UN's direction due to the non-binding nature of the resolution. For instance, in a 366-59 vote, the Brazilian legislature approved the use of embryonic stem cell research (and genetically modified crops). This is a political move which will catapult the predominantly Catholic nation to the forefront of scientific advancement and the center of humanity.

As societal fear of the unknown recedes, history will look upon the prohibition of embryonic stem-cell research as inhumane. Opponents of embryonic stem cell research have often lauded adult stem cells as the ultimate solution to this sticky ethical quandary. Recent studies conducted by Dr. Catherine Verfaillie, a leader in adult stem cell research, have highlighted the potential use of multipotent adult progenitor cells: "Bone marrow stem cells have shown significant abilities at proliferation in culture and differentiation into other body tissues." In other words, certain adult stem cells do not have the

capability to develop into a viable embryo, but possess the capacity to differentiate into tissue other than that of bone marrow. This same doctor, a professed Catholic, recently stood before the Nebraska legislature to fight a bill that would ban therapeutic cloning for the purposes of deriving embryonic stem cells and said "It is most likely that five or 10 years from now if you want to treat disease A, embryonic stem cells will be better. But if you want to treat disease B, adult stem cells will be better." She continued "That's why I think it's important that all universities have both kinds of research." While her opinion doesn't address the issue of whether or not killing embryonic stem cells is murder, it disputes the right-wing claims that adult stem cells are the perfect solution.

Another factor to consider is the plausibility that adult stem cells may one day be rendered capable of producing life. This may sound ludicrous, but so did Copernicus' notion of geocentrism. Sticking our heads in the mud every time our standards of morality are called into question by science, in the name of unwavering conviction will do us no good. The belief that a zygote (the fusion of a sperm and ova) constitutes life is reconcilable with supporting stem cell research without the need for rationalization. One needs only to see through deeply entrenched cultural stigmas and recognize the value of empathy within the context of human relationships. Ask die-hard pro-life advocates whether they would employ embryonic stem cells to save their own lives; the answer is almost certainly no. However, rephrasing the query to include

the life of a child or parent certainly evokes a flurry of ethical contradictions. After all, many assume a pro-life stance because of their unrelenting compassion for the unborn fetus. While readily sacrificing themselves, these individuals are often conflicted when confronted with having to choose between the potential life of a cell and that of their own child, even if they ultimately remain steadfast. In the same vein, scientists must acknowledge the zeal with which the pro-life supporters fight as fueled by compassion instead of fear. Although we don't pretend to be clairvoyant, there are a number of events that will come to pass regarding this perpetual ethical dilemma. Embryonic stem cell research will progress. The US, despite its superpower status, cannot legislate for the world. Science is like a surging river: it can be guided in a certain direction, but damming it will only cause a build up of tension, and a torrent of water when it finally breaks. This tsunami will manifest itself as an ethical labyrinth that not even Theseus could escape. Right-wing groups will continue to condemn stem-cell research, while mainstream scientists categorize them as irrational extremists. US lawmakers have an obligation to ignore their quarrelling constituencies; not to favor progress or religion, but rather humanity itself. Whether we are one cell or billions of cells, humanity exists on a higher plane than merely cytoplasm and DNA. The relationships we have, the connections we forge; the very need for interaction -- love, kindness, friendship--are essential components that gives us our humanity. Embryonic stem cell research doesn't sacrifice one cell for other cells... it prioritizes humanity over a single fertilized pre-implanted cell.

You Don't Own Me... Or Do You?

By Kevin Kow and Alicia Cartwright

Debates concerning embryonic stem cell research often focus on the question of when life begins. Perhaps the more pertinent and answerable questions are: "Who owns this life?" or, "Who has the right to make decisions for this life?"

The use of embryonic stem cells has generated much controversy, triggering furious debates among the public, academic, and religious factions. While the potential medical and research benefits of using embryonic stem cells cannot be denied, many oppose the destruction of a cluster of cells that would, or could, otherwise develop into a full human being. The argument is now focused on defining when life begins; but factions are still divided by religious, social and political principles and beliefs.

Beliefs about the beginning of human life range from conception to consciousness, stopping at almost every point along the way. Those based on religion often focus on conception or implantation as the moment – the moment when the fetus receives a soul. Those who base their beliefs on science range from six weeks, when a primitive heart beats; to ten weeks, when the nervous system becomes responsive; and up to 26 weeks, when a fetus has a 50 percent chance of surviving outside the womb with intensive medical care. Each way of looking at the issue has its faults. While the spiritual beliefs cannot be

supported by the scientific method in the way the science-based ones can, they also cannot be proven untrue. Furthermore, the religious-based idea of conception as the beginning of life is fixed: conception always occurs when the sperm reaches the egg. The scientific beliefs, however, are not quite as fixed, as new medical technology could feasibly affect them, as more is learned about the stages of pregnancy.



While there are many well-founded opinions about the exact beginning of life, it is difficult, if not impossible, to delineate a specific beginning since the entire developmental experience is continuous.

Instead of trying to pinpoint the beginning of life in order to distinguish which stages of embryos are usable for research, one alternative is to determine the legal ownership of the embryo or fetus. The discussion of propriety of embryonic stem cell research will then be delegated to its legal owner. The owner's final decisions can vary, based on personal beliefs.

In considering the legal ownership of embryos, one first has to explore the seemingly simplistic question of the ownership of his or her own life. The most obvious conclusion would be that an individual has sole ownership of his or her own life. However, the answer is not as simple as it seems, or perhaps, as it

seems it should be. Suicide in the United States is illegal. In almost all the states in the US, euthanasia and physician-assisted suicide are also illegal. The implication is that if one cannot choose to end his or her own life, then the life does not belong to the individual at all. Furthermore, capital punishment is legal in 38 states, which means that the state actually owns the right to terminate a life and therefore has ownership over that life. If the state owns the life of some of its constituents, it should, theoretically, have ownership of every individual's life. This is supported by the government's ability to require compulsory military service with a draft.

A look at how the issue of ownership of life figures into the debate about the use of embryonic stem cells in research.

Whether or not those drafted believe the war is right, the government can mandate their service.

There are many occasions when people are given jurisdiction over the lives of others. Examples of these include capital punishment and abortions (if the fetus is considered a life). The concept of a government and/or jurisdiction is that the public transfers its decision-making rights to those in a better position to make decisions. This is especially intriguing, since each member of the jury technically does not own his or her own life (since suicide is illegal), but can yet make a collective decision on another's life. The same is applicable to doctors.

In the well-known 1973 case of *Roe v.*

Wade, the U.S. Supreme Court conceded that the woman's right to abort outweighed the right of the state to protect the unborn fetus, indicating ownership of the fetus. Interestingly, this decision was based on a woman's right to privacy, not on any judgment as to whether or not a fetus is considered a life. However, the precedent set by this ruling on abortion could be applicable to the debate on the use of embryonic stem cells. The conclusion would be that the mother may make the decision. The mother appears to have that right, specifically, and not the father because the courts have also ruled, due to the same right to privacy, that she can abort her fetus without the knowledge and/or permission of the father.

The *Roe v. Wade* ruling does not declare that abortion is legal because a fetus is not yet a human life. This case is an example of social justice and morality (the government's jurisdiction) outweighing religious morality (which should not to be dictated by the government). The same balance is found in the predominantly Buddhist country, Thailand. In Thailand abortion is illegal, except in cases of rape. Furthermore, though the procedure is illegal, abortions are not uncommon or stigmatized. Abortion is therefore illegal for religious moral reasons, legal for social reasons (when a woman is raped), and acceptable for purely social reasons.

In a 2003 case in Bloomington, Indiana a decision that let a baby suffering from Down's syndrome starve to death, was sanctioned by the Indiana Supreme Court. The baby had a blocked esophagus and needed a routine surgical procedure to allow him to eat. The doctor testified that the baby would eventually

grow up with "a minimally adequate quality of life", and decided not to operate. Setting aside the moral issues of the case, the point to focus on is that once again, the Supreme Court allowed the life terminating decision to be carried out by a third party.

Seemingly in contrast with this are laws about organ donation. A person can choose to be an organ donor, suggesting some ownership of his or her own life. However, when a person is incapacitated by brain death, regardless of any records that may indicate his willingness to donate organs, the next of kin (family or spouse) must give permission. So here too is a situation in which one person is given control over another's life. When comparing this idea to abortion, as well as the use of embryonic stem cells, a striking similarity appears. When a person is unable to make a decision due to incapacity, (be it from existing in a pre-conscious stage or from brain death), the rights of the individual are transferred to the next of kin.

An individual in this society does not have ownership of his or her own life. The government that denies the right to take one's own life and reserves the right to take that life itself maintains legal ownership. The jurisdiction over a person's life is given to those considered to be in a better position to make decisions. For a brain-dead individual, that jurisdiction lies with the family. When there is dissent between family members, the jurisdiction falls back to the government and the courts. For a fetus that cannot yet make its own decisions, that jurisdiction should also lie with the family, specifically the mother. Before the 22nd week of pregnancy a fetus cannot

survive outside its mother. The fetus is part of her, and entirely dependant upon her survival for its own. For this reason, the question of when a life begins is irrelevant. The mother should have jurisdiction over the life of her fetus, leaving the option of donating embryonic stem cells for research entirely up to her individual morals.

Stem Cell Therapy: The Future of Medicine? Case-study on Stem Cell Treatment and Parkinson's Disease

By Azatuhi Ayrikyan and Jacqueline Kamrath

Stem cells have been touted as the potential panacea of all diseases known to humankind. In particular, embryonic stem cells can be genetically engineered to differentiate into almost any type of tissue. This tissue can then be harvested for use in organ transplants and regenerative therapies without fear of rejection by the host. Transplants can even be tailored to the individual patient, leading to the advent of "customized" medicine.

One of the most promising fields of stem cell treatment is neuroregenerative therapies, particularly in the realm of Parkinson's disease (PD).

Not surprisingly, the controversies surrounding stem cell therapy have been more visible than the technology itself. Public figures, as far from the scientific community as can be imagined, have spoken out against the use of embryonic stem cells in medical treatment; President Bush and Pope John Paul II are among the world leaders who are against embryonic stem cell research. One of the greatest public concerns is the potential use of aborted tissue in biomedical research. The public, unfortunately, has fallen victim to the media frenzy surrounding this therapy, rather than becoming educated on both the ethical controversies and medical

realities of its application.

The political implications of this ignorance have had crippling effects on the advancement of stem cell therapy, particularly in the United States. In late 2001, President Bush mandated a ban on the development of new embryonic stem cell lines using public funds; the ban took effect immediately following his speech. The Catholic Church has also condemned the use of embryonic stem cells as part of its pro-life campaign. The sentiments of the general public are also deeply divided, in large part due to disinformation on the issue. The purpose of this paper is to provide an understanding of some potential applications of stem cell therapy, and a realistic prognosis of its success.

One of the most promising fields of stem cell treatment is neuroregenerative therapies, particularly in the realm of Parkinson's disease (PD). Because Parkinson's is known to be caused by selective loss of dopaminergic (DA) neurons, it is an excellent candidate for targeted stem cell therapy. Replacing the host's dying dopaminergic cells with stem cells engineered to restore this function could be of incredible benefit to the patient and highlights the importance of stem cell therapy for the future of medicine.

Parkinson's disease is the second most common degenerative disease of the nervous system. Its symptoms begin with decreased motor functions, minimal facial expressions, and rigidity of extremities.

The patient dies within 10 to 20 years after the first symptoms appear. The onset of the disease occurs as a result of loss of DA neurons in the substantia nigra pars compacta, and may be influenced by genetic factors. Mutations in three distinct genes have been linked to this disease. Because the affected cells lie in a very restricted area of the brain and the mutations are recessive, stem cell therapy is a particularly attractive treatment option. Theoretically, the damaged area of the substantia nigra could be grafted with stem cells engineered for DA neuron expression, thereby replacing the damaged neurons and regenerating normal brain function.

Several animal models have been created to test the viability of stem cell replacement therapy in treating Parkinson's. In a rat model of PD, the DA neurons grew to, and sent axons, into the host striatum. Another rat model showed that the grafted embryonic stem cells generated functional DA neurons that restored motor behavior in rats with PD (Sonntag et al., 2005).

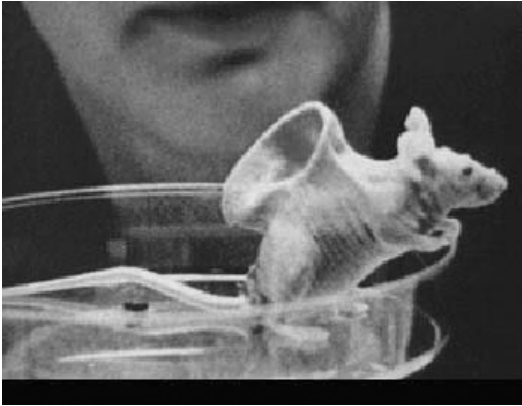
However, several complications arose in animal models examining the efficacy of stem cell therapy. Undifferentiated embryonic stem cells can grow into teratomas or tumors when grafted into nervous system tissue. A method of isolating and purifying differentiated DA neurons from the embryonic stem cells will have to be developed to prevent such complications. Methods for isolation have been developed, ranging from magnetic bead tagged antibodies on selectable markers of DA neurons to green fluorescent protein markers that can then be harvested by fluorescence-activated cell sorting (Doss et al., 2004). The latter method presents the problem of immunorejection by the host,

due to the presence of a foreign protein.

Immunorejection by the host is a very common problem in cell replacement therapy. Although the brain is immunoprivileged, several studies have shown rejection of grafted neurons in nervous system tissue (Sonntag et al., 2004). This immunorejection may be due to the compromise of the blood-brain barrier during implantation. To avoid immunorejection, protocols for implantation into humans must be perfected. Genetic engineering of those cell surface proteins that the immune system recognizes as self versus foreign on the transplantable stem cells provides a way of matching the stem cells to the host and may facilitate successful transplantation.

Finally, the largest complication lies in translating stem cell grafting protocols on rodents to humans. Differentiation time, medium contents, and grafting techniques all must be revised to work appropriately in non-human primates before testing them in people. The work of several researchers in Korea, published this year, shows successful stem cell replacement therapy in a primate model of Parkinson's. They resolved some of the complications in replacement therapy, particularly the isolation of differentiated DA neurons. The researchers identified a growth factor in the substantia nigra that regulates the development of DA neurons in the test tube. The addition of this growth factor to the medium allowed the researchers to develop a large and readily available number of DA neurons for grafting into PD non-human primates. Marked improvements in the symptoms of Parkinson's disease were observed at 10 weeks after transplantation (Hashimoto et al. 2005). These results generated eager anticipation for the translation of this protocol into

treatment of human PD patients using stem cell replacement therapy. Although there is much work left to be done, the near future holds great possibilities for treatment of this terribly debilitating disease. However, that future rests on perfecting protocols and receiving FDA approval, through a process that takes many years and is not as efficient as many clinicians would like.



Many scientists and physicians predict that stem cell research will lead to essential therapies in medicine. Stem cell research evokes thoughts of cures where there were once barely treatments. These undifferentiated cells possess a godlike majesty with their mysterious powers to regenerate new organs or to reverse paralysis. Parkinson's research has even gone so far as to propose that stem cells will restore humanity's most precious commodity, lost brain function. In this way, stem cells have become a bit of the demigod of medical research, a panacea from all that ails picking up where human research left off. How could the general public avoid being swept up in the sensationalism of such technology when it is touted as an elixir of life by media's stem cell groupies?

General representation of stem cell research has been stretched to all extremes so that its reality remains untold. The science has almost been overshadowed by all of the associated bioethical debates. Conservative groups condemn the use of stem cells from aborted fetuses as murder, while various religious groups call such research the commodification of life. Still more conflate stem cell research with the newest generation of gene therapy, dismissing both practices as morally corrupt medicine. On the other end of the spectrum, researchers rave about the regenerative power of stem cells, injecting them into everything from brain to heart tissue. How does the general public evaluate the true potential that may be derived from stem cell research or where to draw the line between pursuing medical miracles and transgressing immutable moral boundaries?

In the aftermath of nuclear technology, some scientists have attempted to divorce themselves from the moral implications of their work. Some scientists have abdicated moral responsibility in the pursuit of pure science. Researchers could no longer be responsible if powerful information fell into the wrong hands of a select few abusers. In the last fifty years, the climate of science has changed. Aided by the ever-expanding presence of the world wide web, the goal is no longer to withhold technology from a select few, but rather to reach as many people as possible. This requires an informed public.

Furthermore, scientists must reflect upon the social ramifications of their work. The effects of scientific research are so far-reaching that it can no longer be performed in a social or moral vacuum.

Science was once called the universal language of man and it should continue to be available to everyone. Public funds should not be devoted to finding cures for diseases that affect only a small few. In addition, they should not be directed towards research that half of the nation does not approve. Scientific technology should be focused on aiding humanity and not so prohibitively expensive that it only widens the wealth gap. All of these decisions necessitate an educated public. Thus, it has become the responsibility of the scientific community to educate the public on their research. In this way, science will speak for itself, rather than find its voice in the most vocal lobbyists. Education of the public in scientific issues should come from those who specialize in the field, but are not divorced from the associated ethical issues.

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II. Genetic Testing

Dangers of Preconception Sex Selection

By Divya K Shah

The human desire to choose the gender of one's offspring is not a new phenomenon. Gender selection has a long history, with methods ranging from special modes and timing of coitus to infanticide. Historically, motives for gender selection have been somewhat less varied than the methods. They generally center around a desire to raise children of a culturally preferred gender or to ensure the economic survival of the family.

In 1902, John Beard of the University of Jena declared "any interference with or alteration of the determination of sex is absolutely beyond human power." Only seventy years later, pre-birth gender selection became possible through prenatal diagnosis and selective abortion. More recently, preimplantation and even preconception techniques have emerged, enabling parents to determine their child's gender at an earlier developmental stage than ever before. The current methods for preconception sex selection can be employed over a continuum of developmental stages. They range from pre-fertilization separation of sperm into those bearing X and Y chromosomes, to preimplantation genetic diagnosis of embryos, to prenatal diagnosis and sex selective abortion.

The technique of spermatozoa separation was invented in the 1980s by the United States Department of Agriculture for purposes of selecting sex in livestock. The Genetics and IVF Institute in Fairfax,

Virginia developed Microsort®, the technology for humans, and currently has the exclusive patent for this technology. The nuclei of spermatozoa in an ejaculated sample are stained with vital fluorescent dyes that permit discrimination between sperm based on the slight difference in total DNA content between the X and Y chromosome. Microsort® costs approximately \$3000 per attempt, and currently claims a 90% success rate for selection of the X bearing sperm, with only 73% accuracy in selecting sperm carrying the Y chromosome.

The public outcry that followed the ASRM's acceptance of preconception sex selection for family balancing illustrates the ferocity of the ethical debate.

Preimplantation genetic diagnosis (PGD) was developed in the early 1990s in order to screen embryos for Xlinked genetic disease, but its use has been extended to include screening for chromosomal aneuploidy, detection of monogenetic diseases, and nonmedical gender selection. The procedure begins with ovarian hyperstimulation, followed by in vitro fertilization (IVF). The fertilized embryos are then biopsied with the aim to determine

the sex of each embryo, and then the decision is made to transfer only embryos of the desired sex back into the mother's uterus. The procedure is available at over 50 centers worldwide, but is costly – approximately \$3000 for PGD and upwards of \$20,000 for the requisite IVF cycles.

The oldest method of pre-birth gender selection involves prenatal diagnosis and subsequent sex selective abortion. Prenatal diagnosis is conducted by ultrasound, amniocentesis, or chorionic villus sampling. The latter can determine gender as early as 12 weeks, ultrasound at 15 weeks, and amniocentesis at 16 weeks. Prenatal diagnosis is routinely offered during pregnancy to screen for a variety of congenital anomalies, and many women elect to learn the gender of their fetus at the same time. While this method of gender selection has been widely used around the world, it is discouraged in the United States and will not be addressed in this paper.

Preconception sex selection was initially intended to avoid the birth of children suffering from congenital or X-linked genetic disorders, and the validity of its use is rarely questioned in this regard. The ethical dilemma surrounding preconception sex selection in the United States thus primarily arises in its use for social, or 'nonmedical' purposes.

Many arguments for permitting preconception sex selection center around satisfying the desire of couples who have strong preferences regarding the gender of their offspring. These preferences may stem from a desire to raise a child of the culturally preferred gender, to parent a child of one's own gender, or to achieve gender balance in a family. Some immigrant communities from Asia and the Mid-

dle East, for example, have a specific preference for male children. In some cases the preference reflects religious beliefs or traditions. Muslim scholars state that while the Quran does not proscribe sex selection, "among the most pressing motivations for sex selection in Islamic culture is the expectation that couples will bear and raise at least one male child of the culturally preferred gender." Other couples with strong gender preferences may place value on the different rearing or relational experiences they think they would have with children of a particular gender. For example, a father who wants a son to make up the distance he felt from his own father, or a mother who wants a girl because of the closeness that she thinks she will have with a daughter. A final group may seek to have a child of a gender different from that of a previous child in order to meet the expectation of variety in their family makeup.

One can question whether parental desire alone, for reasons detailed above, justifies acceptance of the preference to select the gender of one's children. Ironically, few policy makers argue openly in favor of sex selection on the basis of parental preference. Instead, they reach for the principle of procreative liberty, arguing that unless substantial harm to others results from a reproductive practice, couples should be able to act on their preferences for children of a particular gender. In a 2001 report from the Ethics Committee of the American Society of Reproductive Medicine (ASRM), chairman John Robertson supports this view, "if methods of preconception gender selection are found to be safe and effective, there would be no compelling reason to ban or restrict their nonmedical use," and indeed doing

so, “could be found unconstitutional or illegal”.

The public outcry that followed the ASRM’s acceptance of preconception sex selection for family balancing illustrates the ferocity of the ethical debate. While the arguments against sex selection are varied and extensive, they can essentially be divided into those that inherently oppose the concept of parental control over the sex of one’s offspring, and those who warn against the potential individual, familial, and societal consequences should this control be permitted.



The argument that preconception gender selection represents an inappropriate level of control over non-essential characteristics of children is rooted in the philosophical conception of procreation and parenting. The President’s Council on Bioethics maintains that sex selection “treats the child as an artifact and the reproductive process as a chance to design and produce human beings according to parental standards of excellence.” Furthermore, while the parent-child relationship ultimately depends on an attitude of virtually unconditional acceptance, preconception sex selection places excessive concern on minor genetic characteristics rather than the inherent worth of one’s offspring. While many find this argument personally and instinctually compelling, its intersection with ideas of morality and religion make it difficult to apply in a broad secular context. In the public

sphere, far stronger arguments against sex selection are based on the resulting consequences against the individual, the family unit, and the broader society.

The arguments against gender selection can be well contextualized borrowing the concept of ‘negative externalities’ from principles in economic theory. An externality is defined as any effect, positive or negative, on a third party in a transaction. The question of whether sex selection is included among the ‘procreative liberties’ that are enjoyed in the United States is perhaps best addressed in these terms. While American society deeply cherishes individual liberty, it is not without limit – our personal liberties are inherently restricted by the negative externalities that we impose on other individuals and society as a whole. Similarly, the right to reproductive freedom is never an absolute right, but rather a negotiation between the positive externalities that sex selection impose on an individual family and the negative externalities that they impose on children, families, and society.

This line of reasoning naturally begs the question – what negative externalities are imposed by sex selection and on whom are they imposed? The most obvious and perhaps consequential externalities are those that impact the society as a whole: the reinforcement of societal gender bias and the potential for creating imbalance in the sex ratio.

Preconception gender selection promotes sexism by reinforcing the current societal gender bias. This process can occur in one of two manners: by allowing more children of one gender to be produced or by identifying gender as a reason to value one child over another. The first

process directly leads to alterations in the sex ratio, and will be discussed in that context. The second process poses a more insidious risk. It is clear that women in many societies, including our own, have been subject to disadvantage and discrimination solely because of their gender. Even if one's intention in using preconception gender selection is not to harm or denigrate women, acting on the basis of gender preference for offspring lends credence to socially constructed stereotypes of what it means to be a man or a woman. As Savulescu and Dahl (2000) point out in their recent publication in *Human Reproduction*, "if preconception gender selection occurred in a social and legal context where the equal rights and status of women are respected, its use would not deny women equal opportunities or value as persons". By any measure – professional glass ceilings, income disparities, or the recent comments of a certain university president, to name a few – we do not exist in such a context. Opponents often argue that couples seeking sex selection for family balancing – selecting one's second child to be the opposite gender from one's first child - are immune to this social bias. The obvious flaw in this reasoning is that a disparity may still exist between the rate of selection of male children in families that have a female child and selection of female children in families that have a male child. As long as society maintains its gender bias, permitting couples to control the sex of their children will only reinforce it.

A second negative externality that preconception sex selection imposes on a society is that of altering the sex ratio between the two genders. The standard sex ratio is 105 boys born for every 100 girls;

technically, any variation in the sex ratio exceeding 106 boys per 100 girls reflects some element of gender selection. To give a global context, the following table has examples of imbalanced sex ratios (number of boys born per 100 girls) from selected countries (data recent as of 2001 from The President's Council on Bioethics, 2003).

COUNTRY	NUMBER OF BOYS PER 100 GIRLS
Venezuela	107.5
Yugoslavia	108.6
South Korea	110
Pakistan	110.9
India	117
China	117
Cuba	118
Azerbaijan, Georgia	120

The gender ratio in the United States has been stable at 104.8, clearly indicating that imbalances in the gender ratio are not comparable among all regions of the world. It is interesting, however, that these examples span western, eastern, developed, underdeveloped, Hindu, Muslim, and Christian nations. Gender imbalance at a national level may result in a variety of ills – difficulty in finding a mate and an increase in gender related crimes such as rape and prostitution are some examples.

Some may also argue that the United States is a different culture that does not "have a preference for a particular sex." Aside from discounting the clear gender bias inherent in our society, this comment overlooks the diversity of 'American' culture. It is of note that certain American ethnic groups have seen a statistically significant increase in their sex ratios between 1984 and 2000. The ratio for Chi-

nese Americans rose from 104.6 to 107.7, and for Japanese Americans 102.6 to 106.4. This trend has not been overlooked by private clinics that offer gender selection. In August 2001, soon after the ASRM ethics committee condoned the use of gender selection for 'family variety', The New York Times reported an onslaught of advertisements for sex selection targeted towards Indian expatriates, one of the country's fastest-growing ethnic groups. "Desire a Son?" asked one ad in *India Abroad*, a weekly newspaper for Indian expatriates in the United States and Canada. "Choosing the sex of your baby: new scientific reality," declared another in the same publication. A third ad ran in both *India Abroad* and the North American edition of *The Indian Express*. "Pregnant?" it said. "Wanna know the gender of your baby right now?" Similar niche marketing has been emerging in media targeting East Asian immigrants. In order to retain its image as a society built on a foundation of equality, the United States is advised to learn from the experiences of other nations and limit the practice of sex control.

While it is important to consider the negative externalities that preconception gender selection impose upon a society, it is equally vital to explore the impact on the psychology of individual children and families. The primary argument against gender selection in this regard is that in choosing one sex over another, parents are necessarily making a statement about what they expect of that child, based on his or her gender. These gender specific expectations may support existing stereotypes – such as a father wanting a son to fish with, or oppose them, such as a couple wanting a daughter to become president to illustrate the equality of women. Either

case is likely to lead to disappointment for parent and child alike when the personality of a child, irrespective of gender, does not meet expectations.

Preconception gender selection imposes an additional negative externality on family relationships. In practicing sex selection, a parent's acceptance of a child becomes highly conditional, undermining the supposedly unconditional parent-child relationship.

The negative externalities imposed by preconception sex selection – from altering gender ratios to establishing expectations based on stereotyped gendered behavior – impact the child-to-be, the family, a society, and a nation. Unfortunately, the general public condemnation of sex selection has not been mirrored by firm public policy regarding the process. The United States stands alone as the only Western nation able to offer preconception gender selection while lacking a uniform and comprehensive system by which to regulate it. Thus far this country has favored the protection of individual choice and the autonomy of parents, even when we disagree with their course of action. This policy must be reversed, to protect the interests of this generation as well as the next.

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IVF and Age Limits

By Jennifer Laine

On Sunday, January 16th, 2005, Ms. Adriana Iliescu, a 66 year-old Romanian retired professor, became a mother for the first time. Via Cesarean section, she gave birth to Eliza Maria, weighing in at 3 pounds, 3 ounces, and also Eliza's stillborn twin. Both mother and daughter were stable. After nine years of trying fertility treatment, Ms. Iliescu is now the oldest mother on record. Dr. Bogdan Marinescu of Giulesti Maternity Hospital in Bucharest facilitated Ms. Iliescu's pregnancy through in vitro fertilization (IVF). When criticized for his actions, he explained that he respected her "special desire" to have a child, and that she was "exceptional" both biologically and mentally. In her first public appearance after giving birth, Ms. Iliescu defended her right to give birth, arguing, "I'm a normal woman, like any woman who has a child." With the average life expectancy of a Romanian woman at 73 years of age, the unmarried 66 year-old has sparked an intense ethical discussion.

Also in January 2005, a new survey of US fertility clinics, by Gurmankin et al., showed not only that few fertility centers have policies for deciding whom to treat, but also that the clinics' screening practices and beliefs varied widely from center to center. Individual programs set their own guidelines; there is little government regulation of practices using assisted reproductive technology (ART). The investigators of this study sent questionnaires about screening practices and beliefs to the directors of 369 (>95%) of the Society for Assisted Reproductive Technology-associated ART programs. ART programs

reported turning away an average of 4% of their potential patients each year -- 3% for medical reasons and 1% for social, emotional or psychological reasons. The study found that a gay couple, a married woman with a 10% risk of death from pregnancy due to diabetes, and a single woman all had about a 50% chance of being turned away. Fifty-nine percent would turn away an HIV+ woman and 3% would turn away a couple in which both members were blind. Eighteen percent would be very or extremely likely to turn away a couple of 43 year-old adults. Interestingly, many centers did not screen for the qualities that would cause them to turn away candidates. Only 18% of the centers had candidates meet with a social worker or psychologist, yet 80% of them required their candidates to meet with a financial coordinator.

Two major events in the field of ART in one month, the survey results and Ms. Iliescu's record-breaking delivery, fueled an already heated debate whether women in their 60s be allowed to become mothers. Should there be national guidelines for ART centers regarding age limits, and if so, what should those limits be? This paper will look at the arguments both for and against age limits, and will conclude that for the safety of the fetus and the mother and for the well-being of the child, there should be national professional guidelines for the age at which candidates can be treated with ART.

Although the future of reproductive rights in the US remains uncertain, per-

sonal choice regarding procreation has been the prevailing value since *Roe vs. Wade* in 1973. Many argue that by setting guidelines for treatment with ART, the US would be starting down a slippery slope, a road that would lead to ever-increasing limits on reproductive freedom. Telling candidates who is and is not allowed to be a parent is paternalistic. It robs patients of their autonomy. Should a third party play a role in making such decisions about who is allowed to become a parent? By limiting who can benefit from IVF, a double standard would be enforced. While fertile persons have no limits on whether

By setting an age limit, the healthier of the two women might become ineligible to become a parent, solely based on

they can become parents, a person who, for instance, has obstructed fallopian tubes must fit certain criteria for parenthood.

Many argue that decisions about whom to treat should be made on a case by case basis. There are many 55 year-old women who are in better health than the average 35 year-old woman. By setting an age limit, the healthier of the two women might become ineligible to become a parent, solely based on one factor. One could argue that this is a clear case of age dis-

crimination, although age could very well have little or no role in whether a woman would make a good mother. In fact, a recent study from the University of Toronto showed that mothers who are more mature tend to be more affectionate with their infants. The mothers of the oldest age group studied, when videotaped with their infants, displayed more affectionate behavior (e.g., kissing, stroking) than did teen mothers who focused more on instrumental behavior (e.g., fixing the child's clothes). Admittedly, this "older" age group consisted of women who were greater than 26 years of age, but one could possibly extrapolate the data to even older women.

When considering advanced maternal age, most worry about health risks to the mother and fetus, yet there are data that healthy women of age 50 or older who undergo IVF with an egg donor experience similar pregnancy rates and spontaneous abortion rates as do the younger recipients of ART. An article by Paulson RJ, et al. published in *JAMA* in 2002 reported the results of a retrospective analysis of the IVF cycles conducted at an ART program in the US between 1991 and 2001. The study looked at 77 healthy postmenopausal women, with the mean age of 52.8, who underwent 121 embryo transfer procedures. The investigators concluded that "there does not appear to be a definitive medical reason for excluding these women from attempting pregnancy on the basis of age alone." With data such as these, one of the major concerns of advanced maternal age could be nearly eliminated and therefore make national guidelines even more unnecessary.

Lastly, one could argue that if age limits were enforced, older candidates desper-

ate for treatment would go overseas to become pregnant. A recent article in *The New York Times* by Felicia Lee (2005) reported that a number of women are looking overseas for more affordable IVF options. If the US has nationwide age restrictions, women could similarly look to programs without age requirements outside of the US for their IVF treatment. The risk of this is that the doctors abroad have not been, and would not be, the long-term providers of these patients. Also, the standards of healthcare could possibly differ. Would it not be safer for these would-



be mothers to get pregnant at home?

If women were to begin looking abroad for programs without limits, they

should not look to Romania. Due to Ms. Adriana Iliescu's controversial case, the doctors who helped her become pregnant will have to go before a medical ethics board in Bucharest, and Romania will likely introduce a law in the next two years that will set an age limit at approximately 50 years.

There are medical, social, ethical and economic arguments for the institution of national age limits for those who undergo ART. This issue needs to be addressed in the near future, for the number of mothers of advanced maternal age is increasing at a remarkable rate. Between 1991 and 2001, the number of first births per 1000

women of 40 to 44 years of age increased by 70%. In the year 2002 alone, 262 women aged 50 to 54 gave birth.

The national age limit should be set at the average age of menopause, which is approximately 52 years of age. By setting the guideline at this age, it eliminates the double standard argument that many use against ART restrictions. With this limit, fertile and infertile people will have the same restriction. Some might still consider this age discrimination, but at least it is biology's version of it. Although ART is not a particularly *natural* process, it does seem fair to give it a very natural age cut-off.

Although the *JAMA* study cited earlier was encouraging towards advanced maternal age, most of the data are discouraging. A retrospective study published in *Obstetrics & Gynecology* found that mothers of 50 years or older were *three times* as likely to have babies of low birth weight, preterm births and very preterm births compared with younger mothers. The risk of very low birth weight and fetal mortality were approximately twice as high for the older mothers, as well. The mothers of the 50 and over age group were at higher risk than the mothers of 40 to 49 years of age for fetal morbidity and mortality. Also, the rate of pregnancy-induced hypertension in women who are 50 or older and who have undergone egg donor IVF is as high as 35%. Another retrospective study of obstetrical data found that even when age-related diseases were controlled for, maternal age was an independent risk factor for fetal death. The authors of this study speculated that the risk could be due to a failure of the uterine vasculature to meet the hemodynamic demands of pregnancy. Based on the data, it seems

that even if a woman in her 50s is healthy, due to her age, she will be a high-risk pregnancy. By being pregnant in her 50s, she will be endangering the fetus remarkably more than she would have if she had gotten pregnant 10 years earlier.

With these medical complications come extreme costs. Premature babies and the babies of very low birth weight are spending weeks in the hospital under careful watch. Also, many of the older mothers are having twins and triplets, causing earlier deliveries (via Cesarean section), smaller babies and even greater costs to the medical system. These costs could be greatly reduced with earlier pregnancies.

We are in an age of face lifts and Botox injections. Many Americans are attempting to slow down the aging process and are spending millions. Although IVF is a terrific technique to benefit infertile people, it should not be used as a way to ignore the biological clock completely. Americans do not like to be told what they should and should not do, but it seems reasonable that if Americans decide to have a child, they *should* make that decision before the age of 50. Women have had to make this decision within this time frame for thousands of years. Fifty years is a long time to make a decision.

Also, one must consider not only the risk to the fetus, but also the well-being of the child. As doctors, we are ethically committed to do no harm. By having a child around the average age of retirement, a child is placed at a much greater risk of losing his parent during crucial developmental years. Due to evolution, menopause reduces such a risk, yet many are trying to ignore it. When Eliza Maria is 16, her mother will be 82 years old.

Does an octogenarian truly know how to relate to a teenager? Imagine the next generation of drivers: the 16 year-olds of tomorrow will learn to drive from senior citizens. To create a situation in which we are actively increasing the number of children without parents or with parents too old to care for them is socially irresponsible and is unfair to these future children.

Although Adriana Iliescu is a very proud mother, one must wonder if her doctors saw her case as experimental. As science progresses and technology improves, certain doctors and patients will continue to push the limits, whether scientific or ethical, of ART. Although many of us are hesitant to put restrictions on access to reproductive technology, there are strong ethical, medical, economic and social arguments in favor of age limits. The event in life that puts an end to a fertile woman's ability to conceive should also be the time of life that candidates are no longer considered for IVF. Our biology is telling us something. We should appreciate ART for what it brings us, but we should not abuse the technology so as to put a fetus in greater threat or to endanger the well-being of the child.

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Mother or Grandmother? Too Old To Reproduce?

By Jemma Lampkin and Anna Shlionsky

With movie stars and mere mortals alike choosing to have children at later and later ages, one is left to worry - when it is too late to have a child? With the birth of Eliza Maria to 66-year-old Adriana Iliescu in January, 2005, the envelope has been pushed once again. It has sparked debate concerning whether or at what point the government should implement regulation on maximal age of the woman undergoing fertility treatment. Many ethicists and politicians, including Arthur Caplan of the Center for Bioethics at the University of Pennsylvania and Dr. Philippe Douste-Blazy, the French Health Minister, have argued for increased regulation claiming that it is not morally acceptable to permit women like Adrianna Iliescu to reproduce. Nonetheless, the government need not legislate the maximal age, since the birth of children to postmenopausal women is not bioethically reprehensible.

Progress in assisted reproductive technology has been rapid since the birth of Louise Brown, the first "test tube" baby, in 1978 in the UK. Despite the inherent hardships associated with these procedures, they have instilled hope among many infertile couples, who constitute 10% of couples in the US. In addition to building families for young couples of child-bearing age, it has also widened the window of opportunity for more "diverse" cases: older women, single parents, homosexual couples, disabled individuals, and many others. And now, sparking enormous opposition, it has been proven to be-

stow parenthood even upon postmenopausal women.

Some argue that postmenopausal births are unnatural, and infringe on the dignity of human procreation since the infants are born after a woman's biologically defined fertile period (between puberty and menopause). In addition, assisted reproduction procedures, as in the case of Adrianna Iliescu, call for donor eggs, raising the question of true motherhood. Indeed, that is true. But aren't all so-called "assisted" pregnancies unnatural? Isn't a prime goal of medical science



to overcome the obstacles that nature presents, providing people with new leases on life? In claiming that *in vitro* fertilization in Adrianna Iliescu was unnatural, one must not overlook that treating a woman, born infertile, is likewise unnatural. Nonetheless, the latter case is generally

applauded by society. Therefore, treatment of menopause as a condition hindering fertility should merit equal admiration.

Another factor in the labeling of postmenopausal pregnancy as morally objectionable is the fact that any pregnancy in a woman over the age of 40 is, by definition, high-risk. Regardless of age, almost 25% of all expectant patients have one or more complications of pregnancy, not including c-section. By this logic, even young women, who know of a genetic predisposition for complication should not be allowed to conceive.

It is well established that environmental factors are some of the leading causes of high-risk pregnancies. If the government does not regulate the sale of cigarettes and alcohol, two of the most detrimental agents to fetal development and birth, by expecting women, why then would it need to control more natural risks, such as age? As long as clinics inform the prospective mothers of the potential dangers to themselves (diabetes, placental abruption, pre-eclampsia, placenta previa, prolapse) and the baby (chromosomal abnormalities, premature birth), the women should be able to make informed and independent decisions.

Dr. Caplan aggressively states, "Iliescu is too old to be having a baby" and that this birth was "completely unethical and immoral." Yet it is illogical to assume that age is necessarily a negative factor in one's ability to raise a child. A common concern is the death of parents before the child reaches adulthood. But statistics lose their value when considering specific cases and life expectancy calculations are therefore often inaccurate for individuals. The average life expectancy of women in Romania is

73, but this has no bearing on the potential life span of Iliescu, especially considering longevity runs in her family, as she claims.

Another concern is the assumption that physical activity is crucial to the upbringing of a child, and that this is seriously compromised with increasing age. Indeed, one would be hard put to find a sixty-something athlete, but can baseball and soccer really be essential to the welfare of the child? Such a notion would surely limit the reproductive rights of not only older individuals, but also those with disabilities and even your average nerd.

Meanwhile, the advantages that older parents have in rearing children have been largely overlooked. First, the highly invasive, often painful and unreliable procedures are usually undergone by those with great desire for a child. These people have clearly put extensive thought into their decision to reproduce, and therefore have a greater potential to be conscientious and involved parents. Likewise, due to older age and their ability to pay for expensive fertility treatments, these individuals likely have more financial security. Iliescu is a case in point, having accomplished a career as a professor and author, and now having the time and the means to devote to parenting.

The question is, then, which side of the debate is most respectful of a person's individuality and their right to reproduce. The women in question should maintain the maximal degree of control, not ethicists nor the government. Although some physicians may reserve their right to not perform fertility treatments on postmenopausal women, those who believe in the benefit of parenthood for these individuals should be

legally allowed to do so. The government must only regulate private issues, such as reproduction when they are detrimental to society at large. As proven above, this is not the case in procreation of older women. Thus, the matter must be left in the hands of the individual, provided she is fully informed as to the risks and benefits of such a decision.

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Life's First Test

By Tamar Glatt and Alice Zhao

Today, with one tiny sample of blood obtained by pricking a baby's heel, doctors can screen for over 25 inherited disorders that are extremely rare, but usually serious or even life threatening. Each year millions of newborns are tested for treatable genetic disorders. With the advent of new methodology, such as DNA testing, we have improved the specificity of testing for rare diseases and reduced the false-positive rates.

According to the Center for Disease Control (CDC), 4 million babies are screened each year in the United States, and severe disorders are detected in about 3,000 newborns. If discovered within the first days of life, grave illnesses associated with genetic disorders can usually be treated or prevented. Newborn screening programs became crucial with the discovery of a screening test for phenylketonuria (PKU) which made cost-effective wide-scale genetic screening possible. Infants with untreated PKU may appear normal in the first few months of life, but left untreated, mental and motor retardation, poor growth rate, characteristic odor, and seizures or tremors will become evident. However, with early detection and proper dietary treatment, mental retardation is totally preventable and growth and development should be normal. With expedient post-natal genetic screening in the first few days, we can completely prevent a life-devastating disease.

Cystic fibrosis (CF), a recessive autosomal condition, is the most common severe genetic disorder in white populations, with an incidence of 1:2000 to 1:3000. In-

fants born with CF develop progressive lung disease and irreversible pulmonary damage. In children where CF is identified by newborn screening, there is less deterioration in pulmonary function, and significantly better growth than in cases of clinical identification.

In North Carolina all newborns are tested for the 20 rare genetic disorders, including CF. In contrast, South Carolina does not conduct genetic testing on newborns, so the benefits of early diagnosis and immediate treatment are not realized.

Why is there a discrepancy between states? If we have proof that areas with genetic screening in newborns have significantly reduced the incidence of rare diseases, such as CF, shouldn't we establish a national standard so every infant is screened for these rare genetic disorders?

Instead of having individual states finance their newborn screening programs, the federal government should implement a national program that sets a standard across the borders. Presently, all New York infants are screened for 11 mandated disorders, and in pilot studies an additional 30 are covered at no extra cost. However, a short drive away in Rhode Island, only 9 disorders are screened for at the fee of \$59.00. In contrast, newborns in Alabama are screened for 14 disorders for a high fee of \$139.33.

High screening costs, for only a portion of all available tests, result from tight state budgets. According to a 2003 General Accounting Office report, states spent over \$120 million on newborn screening, or

\$20-\$40 per infant, in the 2001 fiscal year. These expenditures supported laboratory fees, such as the purchase and maintenance of a \$400,000 tandem mass spectrometry machine. However, looking at the overall medical benefits, it is clear that early detection can often save money in health benefits.

In particular, the University of Pennsylvania School of Medicine conducted an investigation on the cost per life-year saved and per quality-adjusted life-year saved of newborn screening for Medium-Chain Acyl-CoA Dehydrogenase Deficiency (MCADD) disease as compared with not screening. They found that over the first 20 years of life, the cost of newborn screening for MCADD was approximately 11,000 dollars per life-year saved, or 5,600 dollars per quality-adjusted life-year saved compared with not screening. Therefore, the results indicated that newborn screening for MCADD reduces morbidity and mortality at an incremental cost below the range for accepted health care interventions (Venditti et al., 2003). If newborn screening by for MCADD is a cost-effective analysis, then one test that reports on over 25 genetic disorders is certainly worth the cost and every parents' time.

Federal government funding of regional laboratories would stop unnecessary state spending by allowing states to share screening facilities. To end these interstate health-risk disparities, the government should provide access to free newborn screening for all approved genetic disorders. With recent technological advancements that revolutionize the diagnosis of genetic diseases by detecting more than 25 different genetic disorders with a single assay, we should embrace this simplicity and offer an expansive screening

program for all newborns. Thus, with this undemanding procedure and light cost, we can improve the quality of life of thousands of children every year, saving them from a late diagnosis and life threatening complications that could have been treated.

III. Back to the Future

Moving Beyond Moral Quagmire

By Othell Begay and Neha Jain

Christian doctrine states that the beginning of human life coincides with conception, whereas Eastern doctrines, such as Chinese Confucianism, maintain that life is created at birth. For an increasingly fundamentalist United States, this separation is creating an economic problem. The right-wing Christians within the Bush administration find embryonic stem cell research immoral. As a result, the federal government has pulled the plug on grant money; in many parts of Asia, however, stem cell research is seen simply as science and can proceed unrestricted by government.

Religious convictions in a secular nation, such as the United States, should not be the basis of political policies. Rather, the primary consideration on deciding whether to prohibit or permit stem cell research should be based on other considerations including, callous as it might sound, dollars and cents. Because the United States is committed to biomedical research, funding stem cell research from the federal government would symbolize national support and enthusiasm.

Without US governmental support, long-term global competition - and inevitability of novel technologies arising somewhere else in the world - will become a legitimate concern. If scientists in Stockholm or Tokyo are given a free hand in stem cell research, why should their American counterparts in genetics and biotechnology be shackled?

In fact, countries with liberal policies, such as Sweden, Australia, China, India, Japan and South Korea, are profiting from the Bush administration's restrictions on stem cell research. Many governments see America's reluctance as a golden opportunity to leap ahead in this sector of the biotech industry. The progress made by these Asian countries is "astonishing," said Robert A. Goldstein, chief scientific officer at New York-based Juvenile Diabetes Research Foundation International. They have teamed up with Singapore, the world's leading provider of products and technologies derived from human embryonic stem cells, in funding embryonic stem (ES) cells to find a cure for diabetes.

China's strategy in stem cell research also involves aggressively recruiting students from some of the United States' most esteemed universities to work on cutting-edge stem cell research. Like other foreign governments, China has made it their No. 1 priority to locate and recruit top-notch talent to give their country an economic boost and strengthen their competitive edge. Not surprisingly, many of our scientists are willing to relocate to these countries with the hope that they will be allowed to pursue, without interruption, cures and therapies that - in their most dramatic forms - would allow the paralyzed to walk again. The United States produces some of the world's finest scientists and they need decisive support so they won't be lured away by competing nations.

The money is certainly here.

Proposition 71 in California will allocate roughly \$300 million per year toward stem cell research, whereas in Korea, only \$27 million has been allocated from government funding in the past two years. Funding in many non-European countries pales in comparison to even one American state's contribution.

Although stem cell research is not illegal in the United States, the lack of federal money has left it gasping for support. In Asia, bans on therapeutic cloning do not exist because according to most of their religious traditions, human life is believed to begin at birth. Therefore, embryonic stem cells can be obtained without destroying human life. "We don't have an ethical roadblock," said D. Balasubramanian, chairman of the Indian government's stem cell task force.

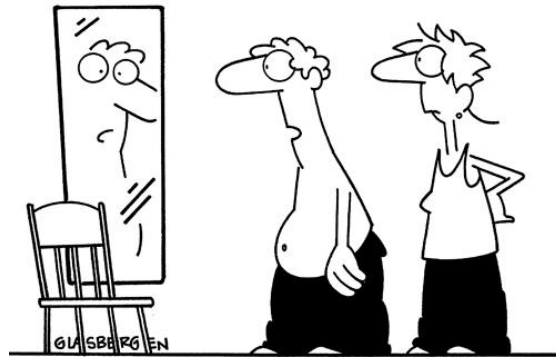
The question regarding stem cell research is simple: Do we want to advance our academic superiority and maintain our position as leaders of scientific innovation or will we allow religious sentiment to hinder economic, scientific, and medical progress? Is a compromise possible?

Stem cell research will not cease because of governmental regulations. The question remains whether government regulations will slow down this research. If the U.S. decides not to cash in on the potential stem cell market, other countries will pounce on it. Countries that opt not to participate in research may find themselves left behind. In addition to losing economic benefits, some of their most brilliant scientists could leave United States Research centers. Still, any expansion of U.S. research during the Bush administration seems unlikely.

The active and enthusiastic support of national leaders plays an important role in science, as demonstrated during our space program by President Kennedy, who pledged to land a man on the moon by the end of the decade - and did it. A nation polarized by conflicting beliefs needs a leader who can untangle himself and examine the issue from an objective viewpoint, much as Gov. Arnold Schwarzenegger has chosen to do in California.

It's a lesson George Bush would be wise to learn.

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"If they make press-on nails for women, why can't they make press-on muscles for men?"

A Drink From the Fountain of Youth

By Steven Kunen and Jessica Midenz

Since the beginning of the human race, there has been an endless search for the so-called “fountain of youth”, which could fulfill the desire to live on for eternity, while never aging a day over twenty. Countless stories have been based around certain life elixirs, magic spells, or even plastic surgeons as today’s fountain of youth; yet it seems that in this day and age we all know better than to expect one magic fix to not only keep us alive longer, but to also keep us young and vital. Scientists at Stanford University School of Medicine, however, have certainly taken a step in the right direction in terms of finding a youth serum. In a paper entitled “Rejuvenation of aged progenitor cells by exposure to a young systemic environment” by Conboy et al., (2005) the scientists provide new evidence that demonstrates that the intrinsic regenerative capacity of muscle stem cells (satellite cells) actually remains intact during the ageing process, suggesting that there is some extrinsic, systemic factor that could theoretically be isolated and dosed out to stop, or even reverse, the ageing process.

The ageing process in cells is generally characterized by a functional decline of tissues, organs, and a loss of the ability to regenerate new tissues. This experiment dealt with satellite cells, whose activation, proliferation, and myogenic lineage progression is known and referred to as the Notch pathway. In contrast to older transplantation experiments, the scientists of this experiment actually formed parabiotic connections between an old and

a young mouse. The controls were two connected old mice and two connected young mice. Through parabiotic connections, the mice developed a shared circulatory system so the satellite cells were only exposed to circulating factors as opposed to other experiments in which actual cells are grafted from one specimen to another. The young mice used were also transgenic for either a green fluorescent protein, or for a distinct allele, which allowed the scientists to confirm blood chimaerism and to distinguish the participation of each

There is some extrinsic, systemic factor that could theoretically be isolated and dosed out to stop, or even reverse, the ageing process.

mouse during tissue regeneration. The scientists damaged the leg of the old mouse of each pairing and observed that in the parabiotic connection between an old mouse and a new mouse, the old mouse’s damaged muscle regenerated robustly in the way that a young muscle would have. In contrast, there was poor muscle regeneration in injured muscle from old isochronic parabionts. Apparently, adult cells cannot properly form the myotubes that produce the necessary myosin of muscle regeneration that younger

cells can.

As mentioned above, the inability of adult satellite cells to regenerate muscle cells after injury is due in some part to an impairment in the upregulation of the Notch ligand Delta. When satellite cells were analyzed from the parabiotic old mice the upregulation of Delta was comparable to that of

young mice, showing that this function was restored through parabiosis, since Delta induction is lacking in old mice that have not undergone parabiosis with a young mouse. The critical part of the experiment came

when the scientists tried to replicate these results in vitro. They cultured satellite cells from old and young mice in either the presence of old or young serum. The results were confirmed: there was increased upregulation of Delta and activation of Notch, which led to the regeneration of muscle tissue in the old mouse. Interestingly, the scientists also determined that something in the old mouse serum was inhibiting function of the young satellite cells. These same results were seen when the scientists looked at liver cells from the mice. Ultimately, this experiment seems to show that the decline of tissue regenerative potential that comes with age can

be reversed, suggesting that intrinsic factors of the cell do remain intact. This study could potentially impact wound and organ healing as well as cosmetic intervention for older individuals. The study essentially shows that there is something in the blood of young individuals that keeps their cells young and vigorous, which means that scientists know exactly

where to look for their youth substance. Scientists could simply isolate every single factor in the blood of the young mice and test them individually, thereby firmly nailing down what exactly the youth

factor is. Once this is done, the factor could certainly be mass produced and our average mean lifespan would probably skyrocket. It seems that at the current rate of scientific discovery, it will not be very long until this youth factor is indeed isolated and found.

It is important to note that this experiment is species specific, so even if the process does work for mice, a similar experimental design would need to be set up for humans to potentially achieve the same results. However, could this type of experiment be easily reproduced in humans? While it does not seem likely that two subjects would willingly join their

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"When I was a kid, I had a lazy eye and it spread to the rest of my body."

physical circulatory systems together as in this procedure, we could foresee a child aiding his or her wounded parent by linking his or her circulatory system through a blood analyzing device that allows for the blood of both individuals to come in to contact? Would it be ethical for a young child to have his/her blood drawn throughout childhood and used for plasma transfusion to maintain the youth of his/her parents? In the Conboy study the purpose of joining the mice together was to heal an injured older mouse, and it was found that the younger mouse's satellite cells could amplify the healing process in the older rat. There may be many lives saved and extended if this procedure could be used in humans.

Many people go to great lengths to prolong the length of their lives. They may exercise, take vitamins, try to eat right, and some may even attempt plastic surgery. It seems that the potential advent of this new youth serum may bring an onrush of people looking who view it as a simple solution to their ageing woes; however, adding youth serum to this list of remedies for old age raises some bioethical concerns. Perhaps it is because of this myth of the fountain of youth, and the idea that people will look and retain all the physiological characteristics they have when they take the serum that makes this issue so important. Nonetheless, by no means does taking youth serum lead to immortality, and if the serum did extend the life of individuals, it would most likely be due to cellular reasons which would not necessarily allow individuals to keep their outward appearance. They may be able to slow down the aging process, but not necessarily look any younger. Yet isn't the entire appeal of the fountain of youth be-

ing able to maintain the visual appearance of youth? We must be certain to communicate clear roles for this new serum so that people do not needlessly medicate themselves, and also create strict regulations for this serum giving it to elderly people who have damaged muscle tissue and not for cosmetic or life boosting potential. Nevertheless, taking a substance specifically for the sake of extending life does not seem immediately problematic; however, if the serum can in fact prolong life, how far can the human life span be pushed? Moreover, is there a certain age that humans should not live past, or should humans be allowed to live as long as medicine can carry them? The answers to these biological and philosophical questions are constantly revised as technology improves.

The implications of potentially outliving loved ones may also be a psychological issue that is difficult to deal with; however, there may be legitimate reasons to categorically dictate the lifespan of any living thing. There have been several medical cases where brain dead patients have been allowed to die because they can no longer participate in the world of the living. Regardless, people do have the unfortunate experience of seeing a loved one pass away at some point in their life. Still, it is important to remember that the length of an individual's life is generally determined by him or herself because they are usually in control of the physical and psychological factors necessary to sustain life. Meanwhile, the average life span is perpetually increasing due to advances in medicine and there have yet to be any serious ethical consequences for those individuals lucky enough to live past 100 years of age. However, with the development of a youth serum, some may begin to

argue that people who live too long are simply a drain on society and the Earth's resources.

Deciding when is too long and who gets to live to what age would certainly be an indeterminable dilemma, yet even individuals who want to end their own life cannot kill themselves legally. Therefore, even if there was a consensus on how long people should live, how could one justify killing that person? This would not be a euthanasia case, but an artificial criterion with severe consequences because we would be imposing limits on life based on age. This could snowball into a form of "agecide". However, there does not seem to be any justifiable reason to see why healthy people should not live as long as possible. If people can have their life spans extended and maintain their quality of life, then any argument against youth serum is vastly weakened. The elderly may even become better contributors to society due to physical improvement. Therefore, we should not be concerned about extending the lives of the elderly because to withhold a potential cure for an ailment that may lead to death is a harsh moral judgment that no person has the authority to make. So, regardless of being able to live longer than loved ones or potentially being a drain to society, everyone has a right to life that they cannot be faulted for trying to fulfill.

Ultimately, it seems that the term youth serum may be misleading for what was actually found in the Conboy study. Since these blood factors have been found only to heal and not necessarily extend life, perhaps this youth serum can be viewed as an extension on current practices involving blood transfusion. The question of obtaining healing treatments

from others has already been addressed because organ donations and blood transfusions are widely practiced with success, and have not resulted in a moral degeneration of society. What this youth serum may promise to do is take the cellular regenerative capacity of younger individuals and make them readily available to older ones, which many may find is not the fountain of youth they had so hoped for.

What this youth serum may promise to do is take the cellular regenerative capacity of younger individuals and make them readily available to older ones, which many may find is not the fountain of youth they had so hoped for.

Nevertheless, there will be those that argue that youth serum could be given as easily as a blood transfusion from a young person. Blood donation is common today. Many people willingly donate their blood to save other individuals, and this is clearly considered an act of moral merit. Why, then, should the blood of younger individuals not be used to aid those who are older? The only difference is that instead of simply replacing lost blood, the blood will be used to treat injuries that the patient's blood is no longer capable of handling as quickly. Athletes may especially find this serum as a beneficial supplement that will help them recover faster, but many athletes are already relatively

young and healthy, so would they even be helped at all? Until the precise cause for heightened regeneration is isolated, it would be unethical and perhaps illegal to introduce this drug to professional athletes especially with their tendencies to abuse other performance enhancing drugs.

Scientifically, the study only showed that liver tissue damage and muscle damage could be effectively treated; no other forms of illness or injury have been shown to improve. What is more, we have not examined the age limits of the serum's effectiveness for either the young serum donor, or older serum recipient. If that is determined, we must see if people who are eligible to donate correspond to these limits. If we must use infants' blood to help heal an old person from an injury, the infant's parents may object to this use because the old person may be literally draining the life out of the infant, causing harm to the young child in the process. No parent would want his or her child to be the human life support for anyone.

Clearly, the race to find a youth serum is only in its beginning stages. Until the precise factors within a youth's blood and the threshold ages necessary for effective treatment are discovered, we cannot make any progress. Once we do isolate the factors, we may be able to extract them from current blood donors and then administer them to patients through a noninvasive method. This kind of process could provide the first effective age resisting serum for humans, or a drink from the fountain of youth, If we could truly provide such a treatment, it would be wrong to withhold it from those who seek to exercise their right to life.

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The Brain on Trial: Waves of the future

By Jackie Kamrath and Stephen Kunen

Would it be just if someone could use your most intimate thoughts and memories against you? Could your own brain be used to convict you? This is the premise behind the latest technology to infiltrate our legal system. Brain fingerprinting is the latest incarnation of the polygraph and it is being used in courts today. Instead of using external, physiological responses as a conventional polygraph does, however, it measures brainwaves to judge a suspect's involvement in a crime. During a typical screening, a suspect is fitted with a special headband that measures brainwaves and is then exposed to images specific to the crime scene. If familiar, these images will trigger involuntary neural activity in the primary visual cortex and activate the P300 wave, which brain fingerprinting recognizes. Thus, if the suspect's brain contains crime specific information, brain fingerprinting will reveal it. At its best, brain fingerprinting is a non-invasive technique that takes about thirty minutes to complete. At its worst, however, it is an assault on our inner most sanctum of mental privacy.

It appears that brain fingerprinting is much more reliable than the current polygraph scan. Its creators at Brain Fingerprinting Laboratories estimate that the test is 99% accurate, whereas conventional polygraph tests are considered 50% accurate at best. Recently, brain fingerprinting was even used to overturn a 24-year-old ruling. After serving more than two decades for the murder of a security guard, Terry Harrington was exonerated after his brain fingerprint showed no recognition of images pertinent to the crime.

Terry's ruling reversal leaves many wondering whether it should be more universally applied. In addition to delivering more reliable verdicts, brain fingerprinting could also shorten deliberation proceedings and thus decrease court costs. This would increase the number of cases heard, potentially revolutionizing the court system.

While the courts aim to maximize justice, brain fingerprinting crosses several ethical boundaries that society may not yet be ready to traverse. The first is mental privacy. Does the administration of a brain-fingerprinting test violate the personal privacy of one's own thoughts? Given the presumed accuracy of the test, are suspects conferring their own guilt if they refuse to take the test? Even today, a suspect cannot be forced take a polygraph unless national security is at stake. Such an intimate violation may also be viewed as a breach of the 5th Amendment. If your brain revealed damning evidence, would this not be the ultimate case of self-incrimination? Although, if we are to trust the accuracy of "brain fingerprints" should the test be mandatory?

The answer is no, simply because familiarity does not equal guilt: this test is 99% accurate at determining familiarity. If this scan were performed on the detectives searching a crime scene, their scans could yield positive results and they are clearly not the guilty party. A person who recognizes a crime scene may pass by that location every day, or have another connection to it that is unrelated to the crime. Conventional investigation is still neces-

sary in order to determine the context of recognition a subject has with a crime scene.

Furthermore, there exists the inevitable danger of confusing the scientific and legal spheres. While the courtroom is certainly no stranger to scientific crime-busting techniques, brain fingerprinting is dangerously touted to be 99% accurate, essentially “infallible”. Whenever the word *infallible* comes into play, however, we have to wonder if we are making a mistake. Its proponents argue that its greatest strength is that it can “scientifically” determine innocence and guilt. Often the term “scientific” is conflated with the idea of truth. However, the certain truth is that scientific conclusions are merely the latest theory in a long line of well-tested hypothesis. Should brain fingerprinting still be considered a means of removing all reasonable doubt? If so, then where should it fall in the hierarchy of evidence?

Consider a case where traditional detective work points entirely to innocence whereas the science blames the suspect. Which method should take precedence? Furthermore, is it ethical to place a scientific seal of approval on a court ruling? It can be argued that such an act would irreversibly pollute the idea of innocent until proven guilty.

Additionally, criminals could potentially exploit this process, using the prom-

ises of brain fingerprinting to extend trials and justify appeals. What was once designed to create peace of mind for victims’ families now provides the greatest defense for potential criminals. What is more, even at its best brain fingerprinting cannot determine intention. Yet, it could play on some subconscious recognition of crime scene details, potentially providing “scientific” evidence against an innocent suspect. However, DNA testing is used to establish guilt at a crime scene even



though it does not determine intention. So, what could tip the balance in favor of brain fingerprinting?

The answer may be rooted in economic, rather than legal objectives. The project originally received \$1million

from the FBI and CIA to develop the technology. Furthermore, if brain fingerprinting were accepted as the national standard for evaluating suspects, one would be put in every courtroom. At \$15,000-20,000 a unit, that is no small sum for taxpayers.

This potentially profound technology should not be limited to the legal arena regardless of its origin. The truth is that no scientific process can confer guilt beyond the reasonable, legal definition of doubt. What it can do is advance the search for truth in the scientific sphere where nothing so subjective as one’s thoughts, guilt, or innocence is on trial.

The Frankenstein Phenomenon: Genius or Tunnel Vision?

By Sarah Harkness and Jessica Stern

There is a colloquialism in science, “publish or perish” that has very dangerous potential. Just as university professors will not obtain the security of tenureship without producing publications, scientists will not receive funding or credibility without putting papers to press. Especially under the constrictions of the Bush administration’s budget for science, publications keep labs open and principal investigators in business. Herein lies the danger; for under pressure, a scientist’s instinct for survival inevitably kicks in. Their identity as researchers can become entrenched in the product even if the means or ends are unethical. At what point does the scientist’s drive for success become blinding? When is it genius? And when is it caused by a sort of tunnel vision that can subvert the ethic of his work?

Recently, the U.S. patent office rejected Stewart Newman’s, of New York Medical College, part human and part animal innovation. Scientists call these hybrid creatures “chimeras”. *National Geographic News* defines a chimera as “a mixture of two or more species in one body.” Over the past years, science has engineered pigs with human blood, mice with human brain cells, and fused human cells with rabbit eggs. We have the technology to create life forms that are part human and arguably subhuman.

By the aforementioned definition, humans who receive average bovine heart valve transplants would be considered chimeras. By ordinary ethical standards, this

is not a contentious procedure. However the most logical extrapolation from this, creating hybrids for the purpose of harvesting organs, is ethically ambiguous. Chimeras could save the lives of patients who require liver transplants, heart transplants, kidney transplants, and a cure for leukemia. Another beneficial use of the hybrid would be for testing of new drugs, surgical methods, or even automotive crash test dummies! They could make a positive contribution to society at large. Therefore, from the perspective of the inventor, the potential for profit and lucrative exploitation of the chimera is legitimately enticing.

Though there is a potential for the Nobel Prize coupled with the innovation of the chimera, the invention, from an ethical standpoint, is highly controversial. What is the boundary between life that is partly human and life that is sub-human? If we create a body to harvest organs for donation, will it have full human rights if it only has half of a human brain? Is it merely a “smart animal”? Or, should we worry about registering the chimera to vote? Chimeras would affix a market value to human life, effectively making it a commodity. This violates the basic principle of bioethics-respect for life.

The human animal hybrid is not named after a super hero. The etiology of “chimera” traces back to Greek mythology; it is a *monster* that is part lion, part goat, and part serpent. Why would science name a hybrid that theoretically should make a

positive and life saving contribution to medicine after a monster? On some level the community must recognize that the creature will not enjoy the rights of a true human being. The very name of this scientific wonder is proof of its unethical origin. So then—how should we judge the scientist who strives to perfect the most lucrative hybrid? If an individual is aware of the dangerous exploitative potential in the chimera, what precisely is unethical? Is it the product or the producer? Hybridized vegetables like the broccoli-flower are not a problem but a hybridized animal that will suffer is. The ethical problem then, is not the hybrid product, but rather the scientist's drive to create such a life form.

Does the culture in science nurture an unethical approach towards innovation? Even Newman, the scientist who attempted to patent a chimera, is not in favor of the innovation. According to the *Washington Post*, he sought to “set a legal precedent that would keep others from profiting from similar ‘inventions’.” As an insider in the community who predicts an exploitation of life, Newman's perspective is evidence for the phenomenon of tunnel vision in the culture of science. There is a fine line between creating a factory to harvest human organs to save lives and creating a subhuman Frankenstein monster. When Mary Shelley wrote her novel *Frankenstein*, she honed in on the survival instincts of the scientist. The drive that fuels the “publish or perish” phenomenon today is analogous to that of Dr. Frankenstein, who robbed graves to enable his creationist experiments. If we can recognize tunnel vision in action, we can keep Frankenstein in fiction and out of reality.

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Researching the Genetics of Homosexuality: The Inherent Bioethics

By Sarah Harkness and Jessica Stern

Lately the scientific community has shown increased interest in researching genes for behavior. Behavioral genes include genes for intelligence, violence, aggression, and addiction. In particular, a number of studies have sought to identify genes for homosexual behavior. There are several biological issues associated with this research; the most fundamental being that human traits are multifaceted and not the result of simple Mendelian genetics. If it is possible to isolate genes for homosexuality, a number of bioethical issues will unfold. They include: unjustifiable funding, and unethical and eugenic applications. The incentive for researching genes for homosexuality is fundamentally prejudiced as it is rooted in understanding gayness as “other” or “problematic.” Ultimately researching genes for homosexuality does not have positive applications for society at any stage of the process and therefore is ethically unsound.

Research in behavioral genetics attempts to explain the role that genes might play in shaping human behaviors such as addiction, sociality, sexuality, and violence. Several recent studies have been conducted to investigate the biological basis for homosexual behavior. These studies have appeared in a number of respected scientific publications and include, for example: “A genomewide scan of male sexual orientation” (Mustanski et. al., 2005); Evidence for maternally inherited factors favouring male homosexuality and promoting female fecundity” (Camperio, Corna, &

Capiluppi, 2004); and “Excess of counter-clockwise scalp hair-whorl rotation in homosexual men” (Klar, 2004). These studies on homosexual behavior have employed several investigative techniques such as genome analysis, hormone level testing, sizing of the hypothalamus, and kinship studies. Although the findings of such research can be intriguing because they contribute to our understanding of what it means to be human, the studies themselves, as well as the results, are ethically

In order to begin research for gene(s) that encode for homosexual behavior, one must face the dynamic between nature and nurture.

ambiguous. There is bioethical contention associated with every step of the research process for investigating the genetics of homosexuality. A recent article entitled “Ethics in Behavioral Genetics Research” in the *Journal of Accountability in Research* by DeCamp and Sugarman is testament to the inherent coupling of bioethical debate and behavioral genetics (2004). It will be seen that researching the biological basis for homosexuality not only involves the ethical issues inherent to any study of genes for behavior, but also entails another layer of bioethical contention as researchers unavoidably confront the issue

of prejudice and bigotry against gays in modern culture.

In order to begin research for gene(s) that encode for homosexual behavior, one must face the dynamic between nature and nurture. As we progress to the later stages of the Human Genome Project, science is finding that nature (genes) can explain more human traits than previously imagined. Never before has the scientific community had so much genetic information within our grasp—we are thirsty to use this knowledge. This thirst sparks interest to research human traits that have never seemed biologically explainable before; like behavioral genetics. Science is in a frenzy to use its new analytical techniques.

As the excitement to use the information obtained by sequencing the human genome builds, science has discovered that phenotypic expression is not as simple as flower color or seed shape in Mendel's garden pea plants. Rather, it is most often the result of multiple genes, and often linked genes. These genes interact with one another in particular cellular environments under the direction of specific transcription factors. Nature (genes) and nurture (environment) are inseparable from one another and cooperative in determining human traits. Therefore, if phenotype in general is a multifaceted result, how can we expect a complex behavior such as homosexuality to be the effect of one gene? Furthermore, how can we expect homosexual gene(s) to be isolable from their environment?

The applications of the genetics of homosexuality are elusive at best. Even if we could isolate genes for sexuality, how would we apply such knowledge? Most of

the options are not ethical.

If we understand that the genetic component of homosexuality (if it exists) is not isolable from its environment, how can we rationalize funding for such arbitrary research? There is no functional purpose for the data. Unlike AIDS studies, for example, which directly impact the length and quality of people's lives, researching genes for homosexual behavior is not so obviously useful. The incentive for such a homosexual behavior study is questionable. One who researches this behavior would have to be recognizing homosexuality as a deviation from the norm. In the act of recognizing homosexuality as "other" or even problematic enough to merit something like NIH funding, researchers themselves engage in an effective prejudice. Homosexuality is not a disease and it does not tax society. Therefore, even the grant writing stage of such a research project would be ethically unsound due the intrinsic prejudice in the project.

In the age of *in vitro* fertilization where parents can learn about their potential offspring's genetic make-up before implantation, the issue of screening babies for behavior genes becomes particularly relevant. If we find a gene for homosexuality, future parents will be able to choose not to have gay babies, by discarding "gay embryos."

Similarly, though in our society less likely, parents can specifically choose to have gay children. In either scenario, doctors and parents would be seizing control over outcomes that had previously been prey to probability, chance, and environmental influences. According to the standards of most Judeo-Christian faiths, this act of "playing God" is unethical. It would

effectively be a practice of eugenics which is generally regarded as immoral.

In Dr. Loike's, *Frontiers in Bioethics* lecture on 8 March 2005, several students suggested the idea that a biological, rather than social, explanation for homosexual behaviors would relieve prejudice towards gays in our society. This argument, however, is fundamentally flawed. Race and sex, for example, are genetically explicable, yet our culture is rampant with racism and sexism. Why then should homophobia be eased by proof of a homosexual gene? In fact, such a finding may exacerbate the problem. Bigots ground their hatred in a false sense of biological superiority. Evidence for the biology of homosexuality will only fuel their hatred, making the quest for such, unethical.

On some level, by finding a purely genetic explanation for homosexuality, we are recognizing the "otherness" of gays as condition akin to disease. To label gayness as a problem, means that we need a solution. An endeavor to find a cure to homosexuality would be unethical for the same reason that finding the gene itself was. We do not need to medicate homosexuality—it is not a sickness or detrimental to society. By researching and isolating the gene for homosexuality, natural human variation would become a stigmatized illness (DeCamp and Sugarman, 2004). We don't want to exacerbate intolerance, and therefore should carefully analyze the true motives for such research.

A gay individual who has been discriminated against all his life may find personal relief in a biological explanation for the behavior that comes naturally to him. He may easily consent to become a subject in one of the aforementioned stud-

ies. If one gay person allows his or her DNA to be analyzed for "homosexuality" though, his or her consent alone does not mean that such research will benefit the gay community as a whole. The sheer existence of such a study will perpetuate the momentum to exclude gays from the heterosexual majority. Herein lays the essential ethical issue, the more we study genes for homosexual behavior, the more we stigmatize it. Imagine if we allocated the same resources, energy, and technology for finding a gene for tolerance. We could hypothetically engineer more tolerant generations of world citizens. Wouldn't society benefit more if we could wipe out bigotry rather than gayness? Though the ethical issues surrounding eugenics are still tied to such a study, the idea barely exists in the scientific community while the genetics of homosexuality are at the forefront of discussion.

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Double-Edged Sword of Progress: The Consequences of Regulating Scientific Literature

By Kevin Jianlin Kow and Constantine Nicholas Lentzeres

In a post 9/11 world, where terrorism dominates the headlines and national security is a hot-button issue, regulating the flow of scientific literature has become an increasingly critical issue. Almost daily, studies are published around the world, adding to an ever-expanding and easily accessible global knowledge base. It is this very ease of accessibility which has permitted such rapid progress in the past few decades, but which has also provided a major point of contention for the scientific and political communities alike. The *Bacillus anthracis* spore, more commonly known as anthrax, has recently stolen the media limelight as terrorism's preferred biological method of attack. Between contaminated mail, evacuations of major government institutions, and the hoarding of antibiotics, it's no wonder that the ease with which information disseminates has come under intense scrutiny. In their quest to combat terrorism, scientists come upon a very disturbing paradox; the very same knowledge which leads to cures can have dire consequences in the wrong hands.

"Efficacy and Durability of *Bacillus anthracis* Bacteriophages Used Against Spores", a recent study published in the *Journal of Environmental Health* (2003), by Dr. Michael Walter, provides detailed information regarding bacteriophages which could at some point be used as a first line of defense against an Anthrax attack. Along with a comprehensive methodology, the paper includes information about where the anthrax bacteria can be

located, the efficacy of the phages against such bacteria, and the environmental factors which affect the phage's interactions with the spore. Examples of information contained in this article that terrorists may apply include: "*Bacillus anthracis* and its nonlethal close relatives are widespread in soils", and ... "Spraying is a method very likely to be used for skin applications of phage-based decontamination techniques." The information contained in this and similar articles presents a tremendous bioethical quandary. Terrorists, with only an internet connection, hypo-

In their quest to combat terrorism, scientists come upon a very disturbing paradox; the very same knowledge which leads to cures can have dire consequences in the wrong hands.

thetically could in minutes discover instructions on how to obtain and cultivate Anthrax spores, obtain studies which highlight inherent flaws in the bacterium so as to eradicate them through reverse engineering, and find the most efficient and rapid means of spore dissemination. The aforementioned study could be used to engineer Anthrax bacteria which are resistant to the phages, or as a manual dictating the environmental factors influencing the propagation of the disease.

Of even graver concern is the study

entitled, "Selection of *Bacillus anthracis* isolates resistant to antibiotics", published in the Journal of Antimicrobial Chemotherapy by A. Athamna et al., (2004) This article discusses information that relates to the primary line of defense against bioterrorism, maintaining the effectiveness of antibiotics against diseases like Anthrax. In just the abstract, the authors write, "The ease with which *B. anthracis* can be made resistant in vitro suggests that close monitoring of patients treated for anthrax is mandatory". Add to that a recipe for creating these resistant strains and a complete battery of antibiotics used against anthrax, bioterrorism becomes easier than building a model airplane. Laboratory supplies can be easily obtained from a number of companies whose bottom line often takes precedence over ethical considerations.

While national security is of the utmost importance, the logistics of performing quality, reproducible, and above all, applicable research are paramount. In both studies cited, the avirulent *Bacillus anthracis* Sterne strain is used as a replacement for the virulent anthrax strain "because of safety and legal considerations." If the Sterne strain is indeed structurally similar enough to the virulent strain, then legal consequences should apply to the usage of both. However, there is no doubt that the avirulent nature of the Sterne strain has enough of a palpable impact to distort results, at least partially.

Articles such as those presented above were no doubt published with the intention of furthering the forefront of scientific research. Knowledge however, is a blinded, double-edged sword. With proper (or improper) application in the wrong hands, terrorists could well use the infor-

mation to create a more potent bio-weapon. They could enhance the mechanisms with which the diseases are spread, or could produce a strain of anthrax that would overcome the effects of the vaccines. For example, other information vital to the efficient production, such as the "optimal" size of anthrax spores for dispersal amongst humans are under 5 microns, is readily available using a quick search over the internet. The same article, published in Human Events, also suggests information on production machinery and other related information. One would expect that research and knowledge on vaccine productions would be more tightly controlled.

Instead, we find that the US government is dependant on private biopharmaceutical companies to produce these vaccines, relying only on the wand of economics as its imaginary collateral. There is nothing to stop these companies, or their employees, from selling their research to the next highest bidder, local or foreign. Take for example, VaxGen, a biopharmaceutical company focused on commercialization of products for the prevention of anthrax and smallpox, currently contracted to the United States to supply a "recombinant protective antigen (rPA) anthrax vaccine candidate to the country's Strategic National Stockpile for civilian use."

Amazingly, instead of tight regulations and control, employees face federal, state, and local laws that every citizen is bound to, but nothing more. However, employees are bound to a Code of Business/Ethics (note the lack of distinction between Business and Ethics) that advises, when confronted with a "business [note *business* instead of ethical], situation

where he or she must determine the right thing to do, an employee should ask the following questions," one of which being, "What would my family, friends or neighbors think of my actions?" The company is perhaps extremely naïve to assume that every employee possesses good moral values. They are perhaps even unintelligent to assume that their employees are all American, especially when their board of directors contain non-Americans. It must also be noted, that a background check is conspicuously missing from the job application's list of requirements.

In a nutshell, the American government outsourced the production of an important vaccine to a private company, which in truth has no jurisdiction over its employees, who in turn, may or may not have the priorities of the US government as their sole motivation. The dependability of this security infrastructure has sorely been ignored in the hopes that market forces will prevail. On a macroscopic scale, the company directors could become future employees of other countries when their contract is ended, using the information on the current vaccines to create a strong, more potent strand of anthrax. On a microscopic scale, single rogue employees could sell valuable research to outsiders, or even release experimental anthrax into the environment, sparking a potential crisis. The main problem lies in selecting whom the holders of this potentially damaging information should be. Should this information be held in the hands of a private company, which is in turn, held by a variety of employees? Should this information be restricted in a governmental body, at the cost of the lack of competitive edge a private company holds?

Resolving this ethical labyrinth re-

quires close governmental supervision of literature propagation which would provide a constant dynamic assessment of the situation without imposing restrictions on research methodology or publication. Terrorism will forever be a force in the world to be dealt with; stopping science will not halt terrorism. The best course of action will be to continue aggressive work in bioterrorism research, keeping ahead of the comparatively limited resources of international terrorist organizations. Only in this way will scientific advancement continue to progress while keeping terrorists as bay.

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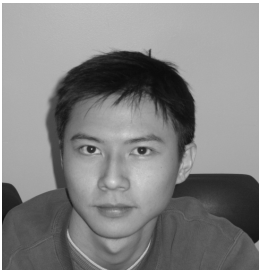
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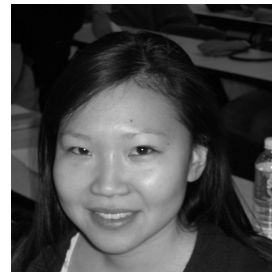
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