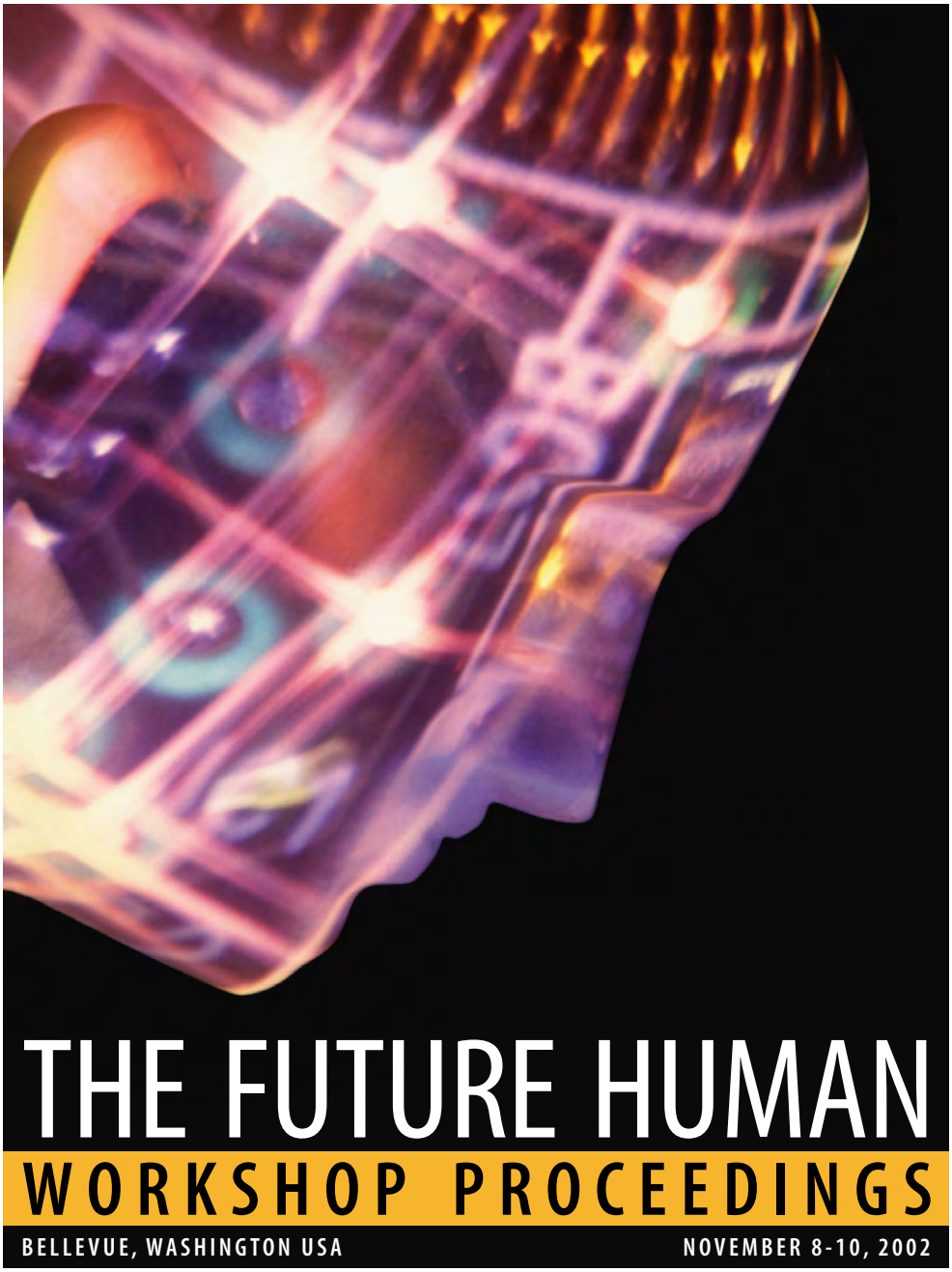


THE FUTURE HUMAN

WORKSHOP PROCEEDINGS

BELLEVUE, WASHINGTON USA

NOVEMBER 8-10, 2002

THE NEXT THOUSAND YEARS

TELEVISION SERIES

Foundation For the Future

123 105th Avenue SE
Bellevue, WA USA 98004

Tel: (425) 451-1333 Fax: (425) 451-1238
Email: info@futurefoundation.org
Website: www.futurefoundation.org

ISBN 0-9677252-7-5

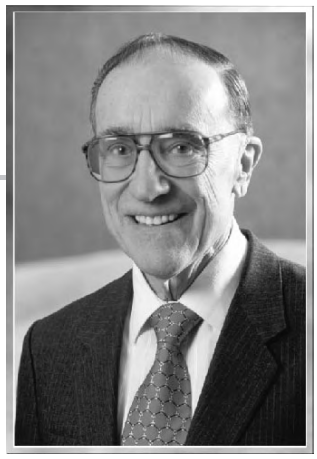
1. Future – humanity. 2. Millennium – Year 3000. 3. Human species – futurology. I. Title.

The comments and deliberations of all participants are deemed very important by the Foundation For the Future. While every attempt has been made to preserve the accuracy of dialogue in the workshop sessions, it is impossible to guarantee that no errors or omissions were made in the course of transcribing and editing the live-session tape recordings. All participants were afforded the opportunity prior to publication to review and amend their comments recorded in this document.

The Foundation advocates no causes or positions. Its goal in publishing the Proceedings of the workshop is to encourage human minds to ponder issues that may shape humanity's future.

A printed copy of this publication is available at cost from the Foundation For the Future. Contact the Foundation for details.

Foundation
For the
Future



May 2003

Dear Readers:

What will *being human* mean a thousand years from now? Will humans be inseparably blended with technology? What will be the impact of genetic engineering? Will further speciation occur? In November 2002, the Foundation For the Future brought together nine scholars whose backgrounds and expertise ranged from molecular biology and biochemistry to sociology and studies of the future. With this base of knowledge, the gathering of scholars addressed these and related questions concerning "The Future Human." This book documents their discussions.

The Foundation For the Future has, since its inception, been focused on research into the factors that will impact the long-term future of humanity. One of its current major programs is planning for a four-part television series entitled *The Next Thousand Years*. "The Future Human" is one of the programs envisioned for this series, and fleshing out content for the program was the main purpose of the workshop.

This book is a record of the November 2002 workshop. I hope you will enjoy reading these discussions about how future humans may change in the centuries and millennium unfolding before us.

Sincerely,

Walter P. Kistler
President and Benefactor

123 – 105th Avenue Southeast — Bellevue, Washington 98004-6265 — 425-454-1222 – fax 425-454-1229 — email: info@futurefoundation.org

Acknowledgments

The Foundation For the Future wishes to acknowledge the following persons for making "The Future Human" Workshop a success:

The participants in "The Future Human" Workshop, whose broad scientific backgrounds and well-informed perspectives were the backbone of the workshop and whose contributions will be valuable well into the future: W. French Anderson, Athena Andreadis, John Campbell, Joseph Coates, Gregory Fowler, James J. Hughes, Gregory Stock, Jeffry Stock, and Burke Zimmerman.

Palfreman Film Group, for developing the preliminary outline of "The Future Human" television program and engaging in searching dialogue with the scholars about the future of humanity: Jon Palfreman, President of Palfreman Film Group and Executive Producer of *The Next Thousand Years* television series, and Barbara Moran, Producer for Palfreman Film Group.

Kirk Citron, for his key role in concept development for *The Next Thousand Years* television series.

Anna Reid Jhirad, Proposal Writer and Funding Consultant, for fundraising.

The staff of the Foundation For the Future, for their dedication and commitment to ensure that event planning resulted in a memorable experience for all involved: Carol Johnson, Programs and Finance Administration; Kathy Carr, Special Programs Manager; Tom Price, Executive Assistant; Jeff Holdsworth, Creative Director; and Jean Gilbertson, PR and Publications Manager.

David Rapka, for capturing the entire workshop on videotape.

Bill Wright, for extensive photographic coverage.

Sherry Anderson, for proofing the Proceedings.

The Trustees and Executive Director of the Foundation, for reposing their patience, trust, and confidence in all of us.

Sesh Velamoor
Deputy Director, Programs

Donna Hines
Deputy Director, Administration

Introduction

***"The Future Human" Workshop was convened to focus on the scientific content of a one-hour television program also entitled "The Future Human," which is one of six programs planned in the Foundation For the Future's first television series,* The Next Thousand Years.**

The television series grew out of the Foundation's ongoing Humanity 3000 program, which regularly convenes seminars, workshops, and symposia to address the question: Where does humanity go from here?

The objectives of the television series are to help an informed public engage with the drivers of change, to understand the wild cards that threaten humanity's survival, to explore the moral and ethical issues surrounding the choices we make, and to examine our ability—and responsibility—to manage the future of our species.

Focused specifically on the evolution of the human species, "The Future Human" evaluates the potential for changing humans in yet-unforeseen ways through advances in genetics and germline engineering, cloning, nanotechnology, and other scientific and technological developments.

In November 2002, the Foundation brought together nine scholars to discuss these advances and how they might shape humanity in the coming centuries and millennium. Their conversations were intended to provide a basis of information for producers from Palfreman Film Group in the development of content and images for "The Future Human" program.

In this television series, as in all its activities, the Foundation For the Future endeavors to fulfill its mission to increase and diffuse knowledge concerning the long-term future of humanity.

Table of Contents

Acknowledgments i

Introduction iii

Table of Contents v

The Proceedings Sections vii

List of Participants ix

Section I Workshop Summary 1

Section II Theme Quotations 3

Section III Scholar Interviews 5

Section IV "The Future Human" Preliminary Outline 25

Section V Transcripts of the Workshop Discussion Sessions 37

V.A Introductory Session 39

V.B Review of Preliminary Outline 45

V.C Discussion of Major Issues 67

Guidelines

V.C.1 Major Issues Session I 69

One Generation (25 Years)

V.C.2 Major Issues Session II 85

Ten Generations (250 Years)

V.C.3 Major Issues Session III 105

Forty Generations (One Thousand Years)

V.D Revisiting the Preliminary Outline 119

V.E Closing Session 139

Appendix I Workshop Agenda 149
Appendix II *The Next Thousand Years* Project Background Notes 151
Appendix III Scholar Biographies 173
Appendix IV Producer and Affiliate Biographies 179
Appendix V Selected Bibliographies of Participating Scholars 181
Appendix VI Selected Articles 193

The Proceedings Sections

Summarized below are the contents of each Section and Appendix of the Proceedings of "The Future Human" Workshop.

Section I summarizes "The Future Human" Workshop, providing an abstract and details on background and purposes, participant selection process, venue, workshop design, description of the workshop process, and key outcomes.

Section II contains four quotations that formed a thematic framework for the workshop.

Section III provides transcripts of five-minute interviews in which each of the nine workshop scholars addressed the question: What is your vision of the thousand-year evolution of our species?

Section IV is the preliminary outline for "The Future Human" program, developed by Jon Palfreman, Executive Producer of *The Next Thousand Years* television series.

Section V provides the transcripts of the discussion sessions conducted over the two days of the workshop.

Appendix I is the Workshop Agenda, noting key activities from the opening reception to closing remarks.

Appendix II, *The Next Thousand Years* Project Background Notes, describes the television series project overall as well as the planned Educational Outreach program.

Appendix III provides biographical information on the scholars who participated in "The Future Human" Workshop.

Appendix IV is biographical information on producers and affiliates who participated in "The Future Human" Workshop.

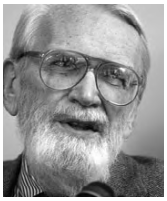
Appendix V provides selected bibliographies of workshop scholar participants.

Appendix VI lists titles of background articles available on the Foundation's website.

List of Participants

SCHOLARS

Dr. W. French Anderson
Professor, Keck School of Medicine
University of Southern California
Los Angeles, CA



Mr. Joseph Coates
President
Consulting Futurist, Inc.
Washington, DC

Dr. Gregory Stock
Director, Program on Medicine, Technology, and Society
School of Public Health, UCLA
Los Angeles, CA

Dr. Athena Andreadis
Associate Director of Research
Neurobiology of Developmental Disorders
The Shriver Center, Univ. of Massachusetts
Waltham, MA

Dr. Gregory Fowler
Executive Director
Geneforum
Lake Oswego, OR

Dr. Jeffry Stock
Professor of Molecular Biology
Princeton University
Princeton, NJ

Dr. John Campbell
Professor of Neurobiology
University of California
Los Angeles, CA

Dr. James J. Hughes
Associate Editor
Journal of Evolution and Technology
Teacher, Public Policy Studies, Trinity College
Hartford, CT

Dr. Burke Zimmerman
President
BKZ Inc.
Oakland, CA

PRODUCERS

Jon Palfreman
Executive Producer, *The Next Thousand Years*
President, Palfreman Film Group
Lowell, MA

Barbara Moran
Producer
Palfreman Film Group
Lowell, MA

AFFILIATES

Kirk Citron
Chief Strategic Officer
AKQA
San Francisco, CA

Anna Reid Jhirad
Proposal Writer and Funding Consultant
The Next Thousand Years
Producer, Marigold Productions
Washington, DC

Section I

Workshop Summary

ABSTRACT

This summary provides an overview of the Foundation For the Future's workshop on "The Future Human," held in November 2002 at the Foundation offices in Bellevue, WA. "The Future Human" is the anticipated title of Program No. 5 of the Foundation's six-part television series, *The Next Thousand Years*.

BACKGROUND AND PURPOSE OF THE SERIES

The Foundation For the Future's first major television series, *The Next Thousand Years*, is an outgrowth of Humanity 3000, an international seminar and symposium series created by the Foundation in 1998. Humanity 3000 brings together some of the most prominent thinkers on our planet each year to discuss and debate the critical factors that may have the most significant impact on the long-term future of humanity. Some 150 scholars from around the world have participated in these seminars, workshops, and symposia.

In the process of reviewing the videotaped conversations of the Humanity 3000 participants, it became evident that the scholars' ideas and their views of the thousand-year future of humanity would make an exciting, educational, science-based television series.

Advances in scientific fields as varied as genetics, cosmology, medicine, nanotechnology, robotics, biology, and ecology continue to push back the frontiers of knowledge. These advances are allowing humankind to project trends and speculate about the future with a greater degree of confidence than ever before. Starting with an informative grounding in the latest relevant developments in various scientific fields, the programs in the series will present a rational approach to examining the various alternative futures that might be possible.

The purpose of the series is to help an informed public engage with the drivers of change, to understand the wild cards that threaten humanity's survival, to explore the moral and ethical issues surrounding choices we make, and to examine our ability—and responsibility—to manage the future of our species. So far, 75 scientists, social scientists, futurists, and other scholars from various parts of the world have agreed to participate in the development of *The Next Thousand Years* series.

The Foundation convened in April 2002 the first Producers Workshop to enable scholars and television documentary producers to discuss the envisioned content and how to create effective television programs about it. With that input, along with suggestions of numerous scholars who reviewed the early drafts of program sketches, the Foundation restructured the series from eight episodes to six one-hour programs, which are expected to air in 2006.

PURPOSES OF THE WORKSHOP

The workshop convened by the Foundation in November 2002 was focused specifically on the content of Program No. 5, "The Future Human." Nine experts in the sciences and futures studies were brought together and asked to discuss, based on their research, what humans are likely to become in the upcoming centuries. The Foundation's objective was to enable the series Executive Producer to learn from the discussions and to have the opportunity to question the scholars at length about specific scientific and technological advances, and the possible impacts to humanity of those advances. The expected outcome of the meeting was that the Executive Producer would obtain the material required to develop the content for the program.

PARTICIPANT SELECTION PROCESS

Scholars were selected for participation in "The Future Human" workshop based on a high level of expertise in scientific fields related to genetics, germline engineering, medical science, biochemistry, neuroscience, and critical technologies that have bearing on the long-term future of humanity. The daily work of the invited scholars focuses on cutting-edge scientific research and uniquely qualifies them to discuss how humans may evolve in the next thousand years as our species begins to defy its biological limits.

WORKSHOP DESIGN

Except for the cocktail reception held on Friday evening before the workshop commenced on Saturday, the entire meeting took place in the Foundation For the Future offices. All sessions of the workshop were plenary sessions. The participants, including scholars, producers, Foundation officers, and affiliates, were seated together in two circles around a conference table. Several observers also attended portions of the event.

Sesh Velamoor, Foundation Deputy Director in charge of Programs, facilitated the workshop overall, though discussion leaders from among the participants were chosen for the major discussion sessions.

The main purpose of the workshop was to provide a forum where experts could address issues concerning the state of the art of science and technology, as well as the myriad of complex issues stemming from them. Though meeting goals were outlined in advance, the format of the workshop allowed for redirection of the content as the discussions progressed.

During breaks, scholars were asked individually to speak on camera for approximately five minutes each on their visions of the thousand-year evolution of humanity. Those videotaped statements join more than 100 similar participant statements already in existence.

The workshop was documented by video footage in addition to this published Proceedings document.

KEY OUTCOMES

By consensus of the participants, the discussions were directed into three divisions: one generation (the next 25 years), ten generations (the next 250 years), and 40 generations (the next thousand years).

The one-generation discussion was led by W. French Anderson, M.D., Director of the Gene Therapy Laboratories at the University of Southern California Keck School of Medicine. Among many concrete outcomes identified for the next generation were the use of genetic medicine to treat or cure most major diseases, the extension of human life-expectancy to 100 years, utilization of nanotechnology sensors, and availability of numerous artificial organs (heart, liver, pancreas, but not brain).

Dr. Gregory Stock, Director of the Program on Medicine, Technology, and Society at UCLA's School of Public Health, led the discussion focused on the next 250 years. Anticipated improvements in ten generations' time include increasing diversity in the human genome as different groups pursue diverse visions of what the future should be, body enhancements for such attributes as world-class musicianship and for extra-human capabilities, brain augmentation, and repair of mental functions.

The third discussion, addressing the thousand-year future, was led by Joseph Coates, President of Consulting Futurist, Inc. Envisioned outcomes 40 generations away include the possibility of extreme enhancements, variations in humankind and even speciation, and translation of consciousness to nonorganic platforms. Global governance, significantly reduced world population, space travel as a necessity, and further extension not just of life span but also of health span were other points of discussion.

Using ideas from these discussions, the Executive Producer of *The Next Thousand Years* television series will refine a treatment for Program No. 5.

Section II

Theme Quotations

Dr. Gregory Stock
Metaman: The Merging of Humans and Machines into a New Global Superorganism

"The coming transformation of humans may well surpass any previous biological transitions in both speed and extent. Future humans will not constitute a sequence of stable, clearly defined forms such as the ones seen in typical evolutionary trees. The human form will instead come to represent a broad variety of potent hybrids between biology and technology."

Dr. Pierre Baldi
The Shattered Self: The End of Natural Evolution

"The completion of the Human Genome Project opens a whole new set of possibilities for biology, biotechnology, medicine, and society at large. A similar revolution occurred when humans first learned to read and write. We are now learning to read and write the language we are made of. But in many ways it is just a beginning and only a piece of a larger revolution that is well underway. Within the same generation, the human brain will face machines that surpass its raw computing power and a world of information-processing devices that makes science fiction pale in comparison. Together these milestones raise profound and troubling questions about the nature and boundaries of life, intelligence, and who we really are."

Dr. David P. Barash
*Revolutionary Biology: The New, Gene-Centered View of Life (*quoting from *Alice in Wonderland)*:

When Alice was lost in wonderland, she asked the Cheshire cat: "Would you tell me please, which way I ought to go from here?"

"That depends a good deal on where you want to get to," said the cat.

"I don't much care where," said Alice.

"Then it doesn't matter which way you go," said the cat.

"So long as I get somewhere," added Alice as an explanation.

"Oh, you are sure to do that," said the cat, "if you only walk long enough!!!"

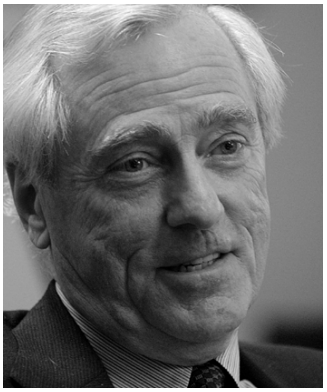
Dr. Edward O. Wilson
In correspondence

"Somehow everything that humans do and are likely to do into the indefinite future will flow from our self-image. At some point we will agree on what we are collectively as a species, what it means to be human, what is human nature, why we are here, and thence, from all this knowledge garnered and sifted, what we wish to become and what we wish to do. Our science and technology to this point have been breathtaking, our self-examination still primitive."

Section III

Scholar Interviews

Each of the nine scholar participants of "The Future Human" Workshop was asked to give a five-minute statement, on camera, to one question: What is your vision of the thousand-year evolution of our species? This section provides a transcript of their responses.



W. French Anderson
Professor of Biochemistry and Pediatrics
Director of the Gene Therapy Laboratories
USC Keck School of Medicine
Los Angeles, CA

What is your vision of the thousand-year evolution of our species?

I think that to look at where we are going to evolve in a thousand years, we need to go back a thousand, two thousand, three thousand, four thousand years, and see where we have come from, what the rate of change is in terms of our development as a human species. If we do that and look at where we are at this point, where we have come in the last thousand years, and the rate of change, clearly that rate of change is extraordinarily increased from what it has been in any previous millennium, which makes the decision about what conclusion to come to of where we will be a thousand years from now very hard to predict.

From a scientific point of view, we *will* understand our genome; we *will* understand our genes; we *will* be able to prevent the vast majority of human diseases; we *will* be able to extend our lifetime; we *will* be able to greatly increase our intelligence; we *will* be able to replace many faulty organs with nanotechnology chips and so on. So, from a technology point of view, we will be able to do many, many things. But what is less clear is that we will have the wisdom to do it in a way that actually makes our human species better. Living 300 years, if that does not go along with a quality of life, is, in fact, 300 years of dying, not 300 years of living.

So, my concern is not technically what we will be as future humans—because we could be a marvelous group of species with all kinds of improvements (whatever improvements are)—but I am not comfortable that we will have the wisdom to be able to make use of these new technologies in a way that will result in less human suffering and a better quality of life. That is why I think this Foundation is so extraordinarily important, because what the Foundation For the Future does is to basically say: "Where is humanity going and how is it getting there?" Not trying to say: "Here is where it ought to go; here is what we ought to do," but a much more reasonable approach in saying: "Where is it going and if we at least start to understand where we are going and why we are going in that particular way, we have some rational hope that perhaps we can be a little more sensible about where we are going than we otherwise would."

Athena Andreadis
Associate Professor of Cell Biology
The Shriver Center
University of Massachusetts Medical School
Waltham, MA

What is your vision of the thousand-year evolution of our species?

The interesting subquestion hidden in that is what it means to be human—not just what we are now, but what we will become. Our definition of *humanity* has broadened. Originally it was the members of our clan. Now it has become that we are at Kardashev Level One, so all of the planet has become one, finally.

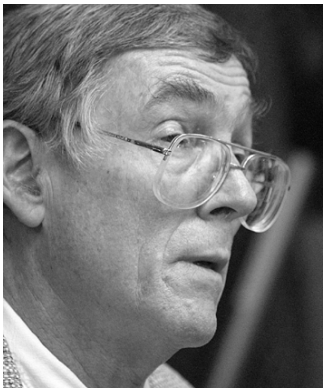
I think that there is no question that in the future, we will have some of what we discussed today; namely, we will have interventions at several levels: augmentations, prosthetics, germline intervention—which are interesting technologies, but they are also going to both expand and challenge our definition of what it is to be human, including, perhaps, interface with silicon. At the same time, I think it is possible that through our tinkering—because humans are tireless monkeys and, in fact, we are mediocre at everything except two things: We are very good with our hands, and we are very good with our minds. Everything else, we are really borderline capacities, but that is why we have been able to expand this part. I think, therefore, that we will expand our definition of *human* perhaps. If we have intelligent machines, they may actually broaden our scope.

But all of this leads us to another point, which is that if we start doing self-designed evolution for ourselves, we may well speciate into subgroups that eventually will become isolated breeding populations, which is sort of a definition of a species. And it may, in fact, also happen even more certainly so if we end up exploring space, if we send out human missions—not just robots. Then, *de facto*, each starship is going to be a new species, because the isolation will be too great.

One of the things we will have to come to terms with, which will be perhaps harder than the technology and what it means in terms of changing, is the fact that we are the starting point for the future—not the crown of creation, not the jewel in that crown, but the beginning.

We have evolved rapidly, and even more so now that cultural evolution has overtaken us and has become almost as fast as we can absorb in our present state. I think all these changes will create stratifications and dislocations, and, being a woman, I know some of the possibilities. It is possible, for example, that if we have womb-free reproductions, women will become trophies or museum pieces—or, alternatively, if we are optimists, we will say, "We will be free of the reproductive part of things and we will finally be equal human beings, and our investment in our children will be the same whether we are men or women." So, you can see either scenario playing itself out, and I cannot predict which one will be the truth.

Of course, people believe this is all transgressive. I don't think so. Humanity, at this point, has tinkered so much with itself and its surroundings that it has no choice but to go forward. There is nowhere to go from here but forward. Although most people talk of the Babel Tower, I come from a different tradition, and my myth for all this is the myth of Prometheus, who stole the fire from the gods. So, I, for one, would like to be alive to see what happens in the next thousand years.



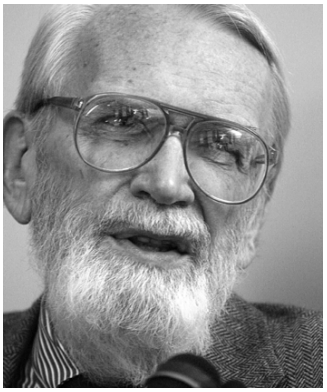
John Campbell
Professor
Department of Neurobiology
University of California, Los Angeles

What is your vision of the thousand-year evolution of our species?

There are many changes that are going to happen in this next thousand years. The one that is going to be most intimate to us will be genetic engineering, where we change our own genetic program. I think this will have enormous potential because it is essentially unbounded, as far as what can be done. Initially our capabilities will be limited by the amount of information we have, and it will also be limited by our resolution, our cultural laws and such. Then, after that—I would say after several centuries when we develop almost a complete information about human biology and genetics—it will be limited by the limits of our mental ingenuity, trying to figure out what are advances that can be made. The significance of that limitation is that it can be overcome by genetic engineering itself, so that we can develop the capacity for making these further advances. I think that is quite significant.

In the past there have been a number of enigmas of existence that we have been able to overcome, we have been able to comprehend. The mechanistic operation of the universe, which until quite recently was ascribed to the workings of a god or gods; the nature of life, what is life? Now we actually understand that, and we are fast understanding genetics and embryogenesis, our development, and such. The significance of this is that these require a substantial intellectual capability for understanding—if you think of how difficult it would be for a chimpanzee to understand quantum mechanics.

In the past we have been able to find out an enormous amount about the universe and, with that, be able to manipulate it, and there are still many aspects of reality that we do not understand: time, causality, mental representations, and such. Probably what we will have to do will be to design new intellectual capacities in order to be able to understand and then to be able to utilize these other aspects of reality that currently we are still in the dark in. So, I think that is where we will be going in a thousand years, eventually developing these new capacities to understand what reality is. I don't know when this will occur; it may occur in a thousand years; it may take 10,000 years. My own feeling is it will take less than a thousand years, but I think it is undoubted that we *will* make progress in this direction, even if we can't understand the particular landmarks along the way.



Joseph Coates
President
Consulting Futurist, Inc.
Washington, DC

What is your vision of the thousand-year evolution of our species?

First, evolution will continue, and the most important development has been, within the past decade or two, that research in genetics now makes it possible—in fact, increasingly real—that we are the first species to be able to directly influence its own evolution. And, of course, we will also be able to influence the evolution of other species: animals, plants, and so on. That is such an unprecedented capability that it is difficult to come to grips with it and understand all the implications.

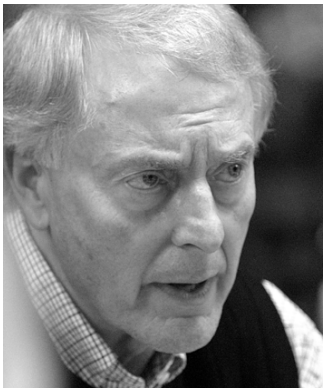
Basically what I see over the long period is that genetics is going to run through a cycle of, first, being able to deal with human diseases and disorders. That is where most of the research is now focused. Then we will move to a phase in which we are enhancing people, basically at a low level of more or less improvement. For example, we already know that parents of children who are perfectly healthy but would only, let's say, have a boy growing to five feet tall, a girl to four-foot-eight, would just love to have their children five or six inches taller. No fundamental change other than what they socially perceive as an improvement. That will follow the dealing with diseases and disorders.

Then coming up close behind that, all the research that would relate to diseases and improvement will eventually lead to human enhancement. And that human enhancement will ultimately work to have some people preferring to have their progeny stronger in some areas, some in another, and by the time the 40 generations or the next thousand years have gone by, we will begin to see new variations in people based upon those accumulated choices.

We already have people who differ in variety: tall, slim, black Africans; short, squat Aleuts; and so forth and so on. But they are all the result of geographic isolation. What is new is that it is going to be the accumulative effect of individual, private choice. In the course of all this unfolding, most of the diseases and disorders that are so important today will disappear or be fully dealt with. That is the mainstream.

Connected with that will be the associated, semi-independent developments in brain science. Some of that, of course, is genetic, and some is not. As brain science develops, we are going to have a technology of the brain, in the ordinary sense of: take it apart, put it together, change it, alter it, improve it. All of those words of technology are going to apply to the brain, and some of the improvements will be genetic; some will be through drugs; and so forth and so on.

Then, of course, the third big change is that the things that trouble us today will all effectively be resolved within the next 100, 120 years. What we have to do is work to develop a perspective of what we really want to do in the subsequent 900 years to shape humankind.



Gregory Fowler
Executive Director, Geneforum
Clinical Associate Professor
Oregon Health and Sciences University
Portland, OR

What is your vision of the thousand-year evolution of our species?

I think that human evolution will not change so dramatically in the short or the long term. The human species is not really all that different from the other cohabitants on this planet, and experiment and chaos have always been characteristic of the natural evolutionary process in whatever millennium we are talking about. I think that the process will probably be faster in the future—perhaps in one generation or less, which is not characteristic of the present time—but substantively it won't change. Essentially the same kinds of selective pressures will be operating then as they are now. We can add genes; we can subtract genes; the outcome is uncertain, just as it is now. The environment—whatever those environments are—will be selecting for these changes. Basically the same kinds of evolutionary processes will be taking place in the future, so that by enhancing, by fixing, by repairing genes, I think we are not going to be making significant changes.

For people, for example, in the future who want to enhance, let's say, their artistic side, we may very well find that they will be looking at their schizophrenic self at that time because of these kinds of unforeseen changes that will occur when we deal gene-by-gene to make differences in human beings. I think that a thousand years from now we will still be trying to think up clever ways to get around these problems. For example, designer babies will probably just be normal kinds of kids that don't end up developing like the parents had wished them to. I think the same will be true of the first clone, as well: It will probably be some kid who just really wants to be as far away from his progenitor as possible.

I don't think that it is possible for us, in this evolutionary future, to be determining what are good and bad traits, any better than we are able now to define those categories. With regard to Stephen Hawking—always an exemplar—he says that he is what he is *because* of his genetic makeup.

We run the risk, in terms of altering our genetic makeup, in reducing our genetic diversity. By eliminating or culling out certain genes in our genomes, we may be losing much of the diversity that we have. Others feel that if we let people, by their own values, simply move into a variety of areas—a thousand flowers blooming at once, so to speak—that this will increase our diversity. But, in fact, that is not likely to happen. I think human diversity really isn't an issue for us anyway; there are going to be lots of people who are going to continue reproducing in the good, old-fashioned way.

So, I think we are not going to see significant changes in the evolution of our species. The robust solution to all this is really a strong democracy, in which these reasonable policies that are put into place will come from participation in an informed and consensual process.

James J. Hughes
Teacher
Trinity College, Hartford, CT
Secretary of the World Transhumanist Association

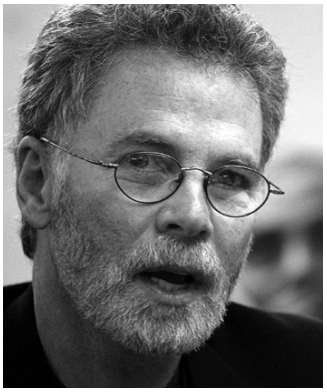
What is your vision of the thousand-year evolution of our species?

If we survive the next couple of centuries, I think that *within* a couple of centuries we will have overcome death; we will have overcome disease and the worst forms of poverty; we will have functional backups of our personality available. We will be well on the way to colonizing this solar system and probably have colonies working on the terraforming of Mars and Europa. And that is just the beginning. If we get that far, then the really interesting questions begin.

I am hesitant about the ability to make solid predictions. I think that things will become incomprehensibly bizarre in some ways as nanotechnology, genetic engineering, and artificial intelligence begin to converge and create technological opportunities that are difficult for us to even think about at this point.

However, there are some eventualities that I think are fairly certain. One is that we will begin to spread beyond the solar system and begin to colonize other parts of the galaxy. Another is that there will be a growing differentiation between the powers and capabilities of nonbiological life and biological life. The limitations of biological life and intelligence will mean that we will be threatened by nonbiological life, and that one of the challenges for the next thousand years is to create a social ecology of all the diverse forms of organic life that will exist at that point—and which I think will be much more diverse than today—and all the diverse forms of cybernetic life and cyborgological life. That ecology will have to learn, just as we do today, to encourage the powerful to respect and aid the weak, and for all those beings—intelligence in all of its forms—to see other intelligence as worthy of respect, as part of the same moral community. That challenge won't go away.

One of the consequences of that is that although, for all practical purposes, death will probably be conquered by the year 3000, taxes will not, because we will still need to have governance, collective decision-making, defense, and so on.



Gregory Stock
Director
Program on Medicine, Technology, and Society
UCLA School of Public Health, Los Angeles

What is your vision of the thousand-year evolution of our species?

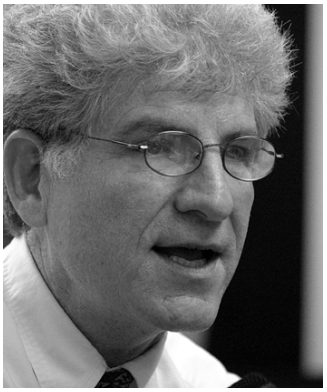
As we are moving through the next millennium, I think that the factors that are going to be important are that essentially we are gaining control over matter; we are learning powerful technologies that can be applied not just on the world around us—we have already applied technologies to reshape the world around us—but now they are becoming focused enough and precise enough that we can turn them back upon ourselves. The challenge is how we are going to use this technology to alter our biology, because we *will* alter our biology, just as we have the world around us.

I think that the major ways that we are going to change our biology are going to be driven by some of the key factors that in the past have influenced our behaviors: Our desires, our wants are shaped by our evolutionary background. Our desire for affiliation, our desire for status among individuals, sexual drives—all of these sorts of things are going to be affected as we move forward. They may not remain exactly the same, but they are always going to be a pathway of change that has echoes of those original drives. The question for us is exactly how they are going to influence what we choose to do.

As individuals, when we change our biology, if we can extend the human life span, if we can gain control over many aspects of our emotional states, the way we deal with emotions, the way we experience emotions, and also over our reproduction, then we are going to do this. And because we are using technology to do this, it means that some of the same forces … it will have the same feel as many of the things that now we look at as outside of biology; for instance, fashion and consumer marketing and product development. These are aspects that will begin to have impacts on the way we look at our own reproductive future.

I believe that a thousand years from now, anything of real value that is possible with germline manipulations and with alterations of our biology as adults is going to probably have diffused throughout the entire human population. There is a question as to whether it would create simply a little elite that would be within a sea of unchanged humans, sort of the "future Amish." I suspect that anything that is of real value—things that lead to increases in life expectancy, added health, those sorts of things—everybody is going to want those, just as everybody wants a cell phone right now or everybody seeks a television set, even in the most primitive of nations. Right now these things are so expensive they are not feasible yet, but the things that are of similar nature—high-tech medicine and such—are available only to a few people, but the price curves come down very rapidly, just as they have with, say, computer technology. The richest person in the world 25 years ago could not buy a computer that would even begin to touch what is available today in a bargain basement store.

You have technologies where there are lesser-developed regions of the world, like in China and other places in Southeast Asia, where the telecommunications technology is actually more advanced than it is here in the United States. That is because the technology has become much cheaper and you can get almost a leapfrogging that occurs. The same thing could easily happen with biological technologies. As there are things of value, they will become applied rather broadly.



Jeffry Stock
Professor
Molecular Biology and Chemistry
Princeton University, Princeton, NJ

What is your vision of the thousand-year evolution of our species?

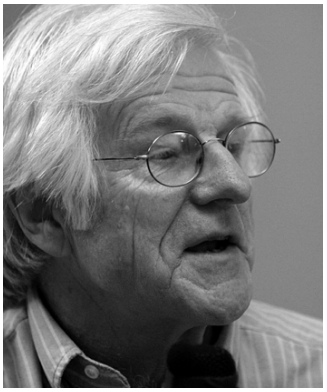
I think the major driving force in human evolution—although a thousand years is really too short a time to be significant in terms of the evolution of the species (the human species at the present time), so I don't think we are talking about what most people would consider evolution—but the major driving force over the next thousand years will be similar to what has been the driving force over the last few thousand years, which is population. The major difference is that we have gone through a period of the last several thousand years of exponential population growth, and that has got to come to an end. That will happen sometime within the next thousand years.

The consequence of that will be that the process that we see as rapid change will start to diminish, so I don't see us continuing on the same course of extremely rapid change or growth as we have been in the past. So, there will be a period of population stasis and probably population decline. It is very difficult to know where that will go in terms of the decline—how far down that will go. What is optimistic and pessimistic is a matter of debate on that score.

What we will look like in the future is clearly mostly Chinese. The gene pool is pretty much established, and it seems very likely that we will be physically more or less Chinese. There has been a discussion of "neck up" (How is our mind going to work?) and "neck down." As any animal—and we are animals—there is an importance more than people imagine in the "neck down" aspect of things. I think our health is very important to us; I think our health is going to improve probably. If one is optimistic and we maintain a cultural integrity during this period, I think our health will improve dramatically. We will be very physically fit; I think we will exercise a lot more than we do now, in the West, at least. I think we will strive toward health. And I think we will live a lot longer, probably somewhere up toward 200 years, maybe, by the end of the thousand years, although this will increase relatively slowly and maybe won't make as dramatic a change as we think. We will still die.

There will be an end of war, I think; people will try to be more safe because they are living longer. That is already happening. I think our lives are relatively safe compared to what they used to be. The big questions about love, sex, reproduction—because we will and we are taking away from that process reproduction, and we will, I think, deal effectively with sexually transmitted diseases, there will be a relatively libertarian attitude toward sex, and people will have sex a lot with each other in the future and be relatively hedonistic.

Finally, there will be, I think, a lot of game-playing, a lot of—more like *Candide*—tending your garden, and that will be because of the need for safety and also because that is what humans like to do. So, I think it will be a relatively decent future and an enjoyable future—perhaps—and not going to space, not as different from the way it is now as some people might imagine.



Burke Zimmerman
President
BKZ Inc.
Oakland, CA

What is your vision of the thousand-year evolution of our species?

First of all, a thousand years is a very short time in the Darwinian timescale of evolution. Without some major events—either through human intervention or through accident—there probably won't be any evolution, either in our mental or psyche evolution or in our physical evolution. However, we now have the tools, through genetic engineering, to force evolution, *if* the products of evolution can in some way survive as first a minority population in a vast majority of unmodified people. This is changing the whole Darwinian scheme a bit if such products of forced evolution are going to make it. We have talked about genetic enhancement, improving intelligence, longevity, resistance to pathology, and the question is, of course, who decides how these changes are going to be made and what the changes actually will be.

One can also view, when we are on the subject of what should be changed: Do we have the arrogance or hubris to decide that ourselves? Darwinian evolution has a mind of its own; there seems to be an intelligence in the way things evolve, yet it is an undirected intelligence. So, from our own 21st century human viewpoint, what is it that we would alter? Clearly, the overall performance of people is something we desire, because we desire this in ourselves: to be smarter, quicker, live longer, healthier, etc. But yet there are other features of human behavior that rest in the limbic system, the midbrain, and this is very primitive historically. This is the seat of emotion and probably most of human behavior. The limbic system and midbrain of my cat and of myself are very similar. It is only the cerebral cortex that has evolved over the last, say, 50,000 years that has enabled human beings to further the motives directed by the more primitive parts of their brain. We can say that wars, aggression, and the kinds of survival instincts that evolved in primitive animal societies or even early human societies are now inappropriate for a so-called civilized planet, so should these things be something we change as well? Eliminating aggression, enhancing altruism, reducing greed and selfishness, which seems to be the dominant value, at least in a capitalist society, and the results are not particularly desirable for most of us.

But in order for this to happen, there has got to be an acceptance in our global order, in our governance, so that any superior minority subpopulation—and it is going to be a very small minority to begin with—stands a chance of survival and not being seen as a threatening alien group and annihilated by the rest of society. As we see, there is no stability at all in world governance, national governance—this is a very chaotic thing and much less predictable than the course of science and discovery.

Barring that, the only way there is going to be evolution is to have a cataclysm that reduces the human population to one percent of what it is, and we are back to surviving against the elements again.

Section IV

"The Future Human" Preliminary Outline

by Jon Palfreman
Executive Producer, *The Next Thousand Years*

Introduction

In Lancaster County, Pennsylvania, we see a child, Marsha Martin, lying on a mirrored bed illuminated by an eerie blue light. The clinic where Marsha is being treated—built with volunteer Amish and Mennonite labor—is a curious mix of high-tech medical personnel and young Mennonite and Amish couples, the women in bonnets and the men in suspenders, babies sitting in their laps.

Marsha has an inherited disease called Crigler-Najjar syndrome. Lacking an enzyme that breaks down bilirubin, a liver waste product, she needs "phototherapy" to stay alive—ten to 12 hours each day lying in a mirrored bed exposed to a light of a special blue wavelength. Crigler-Najjar syndrome is one of many inherited diseases that afflict the Amish community in Lancaster County. Marsha's parents, Miriam and John Martin, of Mifflinburg, PA, have *three* young children with Crigler-Najjar syndrome. Like other Amish, they travel by horse and buggy, and shun technology in their day-to-day lives, but they are enthusiastic supporters of one modern technology: gene therapy. Despite their strong religious beliefs, they see nothing wrong in accepting help from geneticists like Dr. Michael Blaese.

MICHAEL BLAESE: "The Amish and Mennonites are descendants of a small group of Swiss and German Anabaptists who settled in Pennsylvania in the 1700s. Since they were forbidden to marry outside their religion, they married each other. This inbreeding led to very high rates of certain genetic disorders. For some families the situation is absolutely devastating. The only thing that offers them a possible way out is gene therapy."

Blaese plans to correct the mistake in Marsha's genes by trying to insert good copies into her liver cells so they start making the missing enzyme. But one day soon, scientists like Blaese believe it may be possible—if society allows it—to go further and once and for all eliminate this family's genetic curse through genetic engineering.

The scheme works like this: A woman's egg is fertilized *in vitro* with the husband's sperm. Then "germline engineering" is performed on that first fertilized egg to correct the "bad" gene before the egg is reimplanted. Because every cell in the human body descends from that fertilized egg, every cell—including the germ cells that will be passed down to form the next generation—would have the new transplanted genes. This means that the genetic error that has plagued this family for hundreds of years would be corrected, not just for the unborn child but also for all future generations. Not only would *their* child be saved, but all of her descendants would be spared from this terrible scourge.

Germline gene therapy hasn't happened yet … but within a few decades it will be possible. The prospect, at once exciting and alarming, has divided scholars.

FRANCIS FUKUYAMA, Johns Hopkins University: "It's very worrying. While it seems right to help a dying child, or an afflicted family, this medical necessity obscures the bigger picture. If you can engineer the germline to prevent disease, you can also do it to enhance desired traits like intelligence. The door is opened to eugenics and worse. The potential for biotechnology to alter human nature and thereby move us into a "posthuman" stage of history is the most significant threat we face. It may change irreversibly who we are."

LEE SILVER, Princeton University: "Why not seize this power? Why not control what has been left to chance in the past? Indeed we control all other aspects

of our children's lives and identities through powerful social and environmental influences and, in some cases, with the use of powerful drugs like Ritalin and Prozac. On what basis can we reject positive genetic influences on a person's essence when we accept the rights of parents to benefit their children in every other way?"

If germline therapy is decades away, something that is here already is genetic screening. Embryos created by *in vitro* fertilization can be checked before implantation to see which ones possess the disease trait, and those that do can be discarded.

We see a small house in Bethesda, Maryland. The owners, John and Mary Thompson, who are deaf, are eating dinner, signing to each other.

John and Mary are activists for the deaf community. They believe passionately that deafness is a culture and not a disability. Mary and John are expecting their first child and, realizing that deafness can be passed as a hereditary trait, have discussed their concerns about whether their child will be born able to hear or deaf like them. They are seeking a genetic test that screens embryos and determines which ones carry the deafness gene. They have learned about a technique called Preimplantation Genetic Diagnosis or PGD.

Unlike germline engineering, the technology of PGD is here today. Embryo-screening is designed to allow parents at risk for having children with heritable disorders to beat the genetic lottery. Tests currently exist for cystic fibrosis, Tay-Sachs disease, sickle cell anemia, thalassemia, phenylketonuria, spinal muscular atrophy, myotonic dystrophy and one type of Alzheimer's disease. PGD works like this: In a test tube, a woman's eggs are fertilized with the husband's sperm and then the resulting embryos are sampled using a genetic test to see which one is carrying the "mutant" gene. Only the desired embryo(s) need be reimplanted; the undesirable ones can be discarded. For parents willing to discard a potential life, this genetic screening and selection option is already available. But as the Thompsons' case shows, some complicated issues are looming.

In a remarkable twist, John and Mary Thompson want to use this technology not to *eliminate* an embryo with a deafness gene, but to *select* embryos that possess it. For them deafness is a desired trait, not a disease.

JOHN THOMPSON: "We believe that a hearing child will not have as full a life as a deaf child in our family. We live in a community of deaf people. To us, deafness is not a disease; it is a gift. We want our child to have that gift."

The Martins and the Thompsons are two families caught in the middle of a genetic revolution. Their two examples are just a taste of the ethical dilemmas that face society as reproductive technologies literally threaten to redefine who we are. In addition to germline engineering and PGD, there are many other developments that threaten to upset (for better or worse) age-old traditions of birth, procreation, and death. There are, for example, cloning and stem cell research—part of a bold vision of what has been called "regenerative medicine" that will, it's claimed, enable the body "to repair itself." By conquering the major degenerative diseases, this vision of medicine promises to greatly extend life spans. Other scientists have already increased life spans of certain animals through genetic manipulation by a factor of six and believe that human longevity can, in principle, be extended by genetic means.

While many of these techniques have resulted from well-intentioned medical research, they raise questions that go way beyond science. What seems certain is this: We seem to be on a path that will, over the next few centuries, lead us to redefine who or what a human being is.

GREGORY STOCK: "Throughout all of history until the present, life has been shaped by the natural forces of evolution by natural selection. We are seeing the beginning of a profound change: a world in which sex and reproduction become separate, a world in which our children are designed rather than leave their fate to a "genetic lottery,"… a world in which humans may live many hundreds of years. Evolution is no longer beyond human reach. Henceforth some humans will start to self-direct their own evolution. For better or worse, we are gaining the power to redesign ourselves." Not *some* humans, but humanity as a whole.

The fact that we humans *can* do something does not mean that we will choose to do those things. True in general, but I believe that the argument that we will proceed down this path is compelling, and we need to explore the consequences—spiritual/social/political—that will attend this journey. While we cannot predict the future with any great certainty, we can be sure that profound issues are at stake—issues that need careful discussion and consideration. The decisions we make today will determine which of many paths humanity takes—choices that may, over the course of a few centuries, lead to extraordinary ramifications. With contributions from theologians, ethicists, philosophers, scientists, and engineers, this program will seek to advance intelligent debate in this complex and important area. From Aristotle to the Human Genome

Project, from Confucius to machine intelligence, this program will seek to fuse the spiritual and the scientific.

Biotechnology: The Promise and Perils

James Watson, Francis Crick, and Maurice Wilkins receiving the Nobel Prize in medicine. We cut to Wilkins in London, now active in the British Society for Social Responsibility in Science, which challenges the future unfettered development of molecular biology.

Maurice Wilkins is one of a trio of scientists who made perhaps the greatest discovery of the 20th century. In popular scientific legend, Wilkins, together with James Watson and Francis Crick, discovered the secret of life. In fact, it wasn't *the* secret but *a* secret—a very important one—the structure of DNA. Today the three men lead rather different lives. James Watson has become a leader in biology and for a time led the Human Genome Project. Francis Crick became more interested in understanding the human brain and now works at the Salk Institute. Maurice Wilkins has increasingly devoted himself to speaking out about the social issues raised by the new biology. Watson and Wilkins have come to very different conclusions about the science they helped start.

Wilkins started life as a physicist who did work connected with the atomic bomb project. Horrified by what happened in Hiroshima and Nagasaki, he decided to switch to biology, feeling that nothing as bad could flow from biological research. His switch was motivated by reading an extraordinary book by the Austrian physicist Erwin Schrodinger entitled *What Is Life?*

MAURICE WILKINS: "This book changed my life. From the moment I read it, I realized that I would devote the remainder of my career to exploring the living world. The book started with a simple question and with the brilliant precision of a physicist's mind, Schrodinger led the reader directly to the conclusion that the entity that passes life's traits from one generation to another—the gene—must be a large molecule. Life in all its magic was at root simply fancy chemistry. Pretty soon we realized that the key chemical of inheritance was a substance called DNA. That's what led me to my work, and what led Jim and Francis to their breakthrough."

After Watson and Crick showed that DNA was shaped like a double helix, connected with four chemical bases, other scientists went on to explain how such a simple molecule could be a blueprint for life—manufacturing proteins, cells, tissues, and organs.

The discovery of the structure of DNA started a new science, molecular biology, a science with enormous promise for good. A tiny error on chromosome 12, for example, causes children to be born lacking a key liver enzyme. Left untreated, children born with this genetic disorder—called phenylketonuria—develop mental retardation. But just because something is genetic—scientists argued—doesn't mean it is unchangeable. Doctors discovered that by putting such children on a special diet, they could avoid the problem and enable the children to grow up with normal intelligence.

MAURICE WILKINS: Helping children with phenylketonuria is a wonderful use of molecular biology. Unfortunately it doesn't stop there. Any technology for power to do good also has potential for great harm. I had no idea initially that molecular biology would lead to things like cloning … genetically modified salmon … germline engineering …. I've since realized that the science I helped start needs careful oversight, perhaps even more than nuclear physics. Because it affects the sanctity of who we are."

Watson and Crick feel quite differently.

JAMES WATSON: "Terms like *sanctity* remind me of animal rights. Who gave a dog a right? This word *right* gets very dangerous. We have women's rights, children's rights; it goes on forever. And then there's the right of a salamander and a frog's rights. It's carried to the absurd …. I'd like to give up saying *rights* or *sanctity*. Instead, say that humans have needs, and we should try, as a social species, to respond to human needs—like food or education or health—and that's the way we should work. To try to give it more meaning than it deserves is just plain—I mean, it's crap."

That two colleagues can end up with such disparate positions is revealing. Biotechnology both excites our wonder and elicits repugnance.

In 1953, when Watson and Crick published their paper on DNA, babies were made the same way they had always been made: by sexual reproduction following a union between a fertile man and woman. A lot has happened since.

Reproductive Medicine: Social Changes, Daunting Dilemmas

The pill and other later birth control devices, and the legalization of abortion in most countries, enabled women the option of having fewer children. It worked better than anyone imagined. Today in Western Europe many countries produce little more than one child per couple on average. Populations are falling and aging.

Better prenatal care led to a great reduction in the infant mortality rate. But screening methods have led to some unintended consequences—especially in Asia.

GREGORY STOCK: "Even with relatively low-tech screening methods, a change in the human species is well under way. Sex selection has been possible for more than a decade and, while illegal, it is widely practiced, especially in Asia. In South Korea, boys outnumber girls: There are 122 boys born for every 100 girls. The rates are similar in China. This signals the beginning of a fundamental change in our species. Within 20 years, up to a fifth of all Chinese males will be unable to find brides from their generation."

Meanwhile the plight of childless couples unable to conceive through traditional sexual means led scientists to develop *in vitro* techniques, resulting in 1978 in the first "test tube baby," Louise Brown.

While bringing joy to countless childless couples, *in vitro* techniques were used for things that its inventors never intended—things that had never occurred before in evolution. Today, *in vitro* technology allows women long past the age of menopause to give birth, and permits widows to have children with the sperm of their dead husbands. Some *in vitro* cases raise bizarre dilemmas that keep academic philosophers on their toes.

DANIEL CALLAHAN (Hastings Institute): "Take the case of Janet M. She is not your average mother. Janet is a 42-year-old, single mother with two sons, four and six years old, both of whom were conceived using anonymous-donor sperm. A few months ago, Janet moved from Los Angeles to San Francisco to take a new job and to be closer to her widowed father. Janet comes to a fertility clinic for a third child, again using donor sperm. After one *in vitro* fertilization cycle using donor sperm, Janet learns that she has poor-quality eggs. To become pregnant, she would need a donated egg. Here's where it gets weird. Because she badly wants genetic connection to her child, she requests that *her father be the sperm donor*. She would use an anonymous egg donor. In this manner she would be able to maintain a genetic link through her father and still experience pregnancy. Her father says *yes*.

What are we to make of such a scenario? Is what is being proposed incest? Is it an abomination or is it a reasonable use of the options provided by genetic engineering?

Leon Kass, head of the Presidential Committee on Bioethics, has a word for what most people feel on hearing such a case: *repugnance*. He feels the repugnance of ordinary folks contains a folk wisdom that has been lost by scientists and professional ethicists.

LEON KASS: "Biotechnologies are providing powers to intervene in human bodies and minds that go beyond the traditional goals of healing the sick, to threaten fundamental changes in human nature and the meaning of humanity. These technological changes have brought us to a crucial fork in the road. We are compelled to decide nothing less than whether human procreation is going to remain human…whether children are going to be made to order rather than begotten, and whether we wish to say *yes* in principle to the road that leads to the dehumanized hell of *Brave New World*."

Kass started life as an enthusiastic researcher in molecular biology at the National Institutes of Health. Today he passionately opposes the unrestricted development of genetic engineering. His views are shared by many humanists, philosophers, and theologians.

Science and technology have always challenged beliefs about the nature of humanity. The world's religions have had to accommodate discoveries about the creation of the universe and the Earth's place in it; they have had to acknowledge the scientific theory of the origin of humanity and the human animal's relationship to other living things. But the scientific advances of the past 50 years in science pose perhaps the greatest challenge to our self-image. If human evolution can be self-directed, if humans can be redesigned, then what happens to our beliefs about human nature, human rights, and human dignity—beliefs that underpin our religious, political, and legal institutions? What happens to long-established constructs like free will and consciousness?

Unlocking the Human Genome

The Laboratories of Celera.

Some scientists believe that changes in the human species are unavoidable because of an explosion in knowledge that has already led to technologies that offer couples choices as to what kind of baby they will have. In 2001 the first draft of the human genome was published in the journals *Science* and *Nature*. Craig Ventner, the scientist whose company, Celera, produced one of the drafts, believes that within five years he will be able to sequence individual genomes to order, for a price tag of $1,000. To start with, the information—-probably put on a CD—will be a novelty. But not for long.

A helicopter shot reveals the striking terrain of Iceland. We find ourselves in Reykjavik watching people walking down the street. We see a man, Stendor Hjorleifsson, turn into his house where he is greeted by members of his family.

Here in Iceland, scientists have embarked on a remarkable project that shows the value of genomic information. It may lead to cures for many of the world's major diseases. Icelanders are descended from a small num-

ber—less than 20,000—of founders who settled the islands between AD 870 and 930. Few settlers arrived after the tenth century, so most Icelanders can trace their lineages back to a founding ancestor. These factors have made Iceland a very attractive place to start teasing out the function of the 30,000 genes in the human genome.

Stendor Hjorleifsson's family have suffered from an inherited form of asthma for as long as anyone can remember. Careful genealogy has revealed it to have originated with a single couple in the 17th century. The Hjorleifssons are now part of a study to find this asthma gene and many other genes—a study that involves virtually the entire Icelandic population.

The DeCODE company in Reykjavik, Iceland.

Kari Stefanson, founder and CEO of DeCODE Genetics, is managing the project for the Icelandic government. His database contains the details of 650,000 individuals stretching back over 1,100 years. By matching gene profiles from blood samples donated by local people against family histories and health records, he plans to track genes across the generations.

KARI STEFANSON: "We will be able to track tiny variations in DNA called SNPs (single nucleotide polymorphisms) down multiple generations and find genes involved in all the major illnesses. These novel genes will direct the search for cures for everything from cancers to Alzheimer's. We have already found some genes related to schizophrenia."

DeCODE has lots of competition. Scientists and companies everywhere are trying to ferret out what each of the 30,000-odd human genes do. Identifying the genes implicated in major diseases like Alzheimer's and cancer is just a start. After that, genes involved in behavior will be identified and then genes that are involved in nonmedical attributes like IQ, musical ability, athletic prowess, and so on.

As more and more genes' functions become known, the value of personal gene scans increases. Ventner believes that even without projects like DeCODE's, progress will come rapidly. With so many genomes being sequenced (at $1,000 a pop), scientists will also be able to use simple brute-force statistics that will correlate genes to traits—initially disease traits. This will speed the task of identifying what all the human genes do.

But it won't end there. The information will identify genes for positive traits as well, and this knowledge, once out in the world, may be acted on by prospective parents.

Some companies are already developing the technology to rapidly screen individual genomes for genetic variants. This gene chip made by the California company Affimetrix can potentially screen for thousands of genes at a time.

GREGORY STOCK: "What is unavoidable is that the very same technology that is so useful for medical research could easily be used to screen new embryos for genetic traits. Once we know the various forms of genes involved in, say, IQ, mood, musicality, etc.—we don't know them yet, but we will in a matter of decades—we will be able to look to see which ones are present in an embryo and then we can select the embryos with the traits we desire. Today the genetic lottery of sexual reproduction guarantees that the son or daughter of a parent will not necessarily inherit his or her talents and abilities. Germline engineering reverses the "unfairness" of this genetic lottery, making good genes a matter of choice, not accident of birth. Another approach scientists are working on is artificial chromosomes. By adding a new pair of artificial chromosomes to the embryo (chromosomes that have been engineered with all the latest genetic enhancements), designer babies could be produced."

The Human Genome Project has proceeded so rapidly that it is highly probable that in a century or two most of the mysteries of biology (which took millions of years to evolve) will be understood and mastered. Some scholars have argued that one danger of this technology is that in the future, social elites may be able to control the genetic odds for their offspring. Will this undermine the notion of universal human dignity and lead to a bifurcation of the species into Genrich and Genpoor humans?

FRANCIS FUKUYAMA: "The notion of human equality is fundamental to many societies. In politics humans are accorded special rights—to vote, for example—based on a presumed special essence that no animal or machine possesses. Even though the rich and successful can pass on privileges, they can't take away rights and they can't so far embed advantages genetically. Will genetic enhancement destabilize our political institutions? I think that we should be acutely concerned."

The Nature of Human Nature

Many scientists (and many ethicists) belong to the philosophical school called *utilitarianism*, which seeks to satisfy human needs and interests without reference to rights.

But our political and legal institutions assume that beyond human needs and interests are things called

rights. The framers of the US Constitution presumed rights to exist when they wrote "all men are created equal."

But from where do rights derive? Many of the framers believed they derived from God. Other philosophers throughout history have sought to base them in nature. A third school thinks of rights as mere conventions that have arisen in certain societies. In this last school, there are really no universal rights.

Francis Fukuyama realized that to disprove utilitarians like Watson, he had to show that there was such a thing as natural rights that derived from nature. He had to show that humans are the way they are because of something about us that is special and natural. From writing to the internet, human beings have changed in so many ways since they emerged some five million years ago, but what has stayed the same? What is that "essential humanness" that is threatened by genetic engineering?

FRANCIS FUKUYAMA: "Human nature is the sum of behavior and characteristics that are typical of the human species, arising from *genetic* rather than environmental factors. What do I mean? Well, take any trait that humans possess, say, height. It tends to be distributed in the population like a Bell curve. Now, if we looked at people 500 years ago, they would on average be much shorter than we are, but the *distribution* of heights would be the same. Changes in the environment—nutrition and health—have raised the median height, but not the distribution. This kind of variation among humans is driven by the way we reproduce and the genetic lottery of each generation. But now imagine changing the lottery through genetic technology to control the outcome. Pretty soon, what has always been human is no longer human."

Right or wrong, Fukuyama's "statistical" definition of human nature is threatened directly by innovations like germline interventions or embryo screening, which, for example, were used to select only children with high IQs.

FRANCIS FUKUYAMA: "There are good, prudential reasons to defer to the natural order of things and not to think that human beings can easily improve on it through casual intervention. This has proven true with respect to the environment … so, too, with human nature."

But the utilitarians think that leaving it all to nature is ethically indefensible. Fukuyama, they argue, has committed the "naturalist fallacy." Simply because "human nature" *is (or has always been)* one way does not mean that it *ought* to be that way. There is nothing so wonderful, they argue, about nature in the raw.

JAMES WATSON: "Evolution is a blind and pitiless process. To simply accept it as natural law is really absurd. We've got to go ahead (with germline therapy) and not worry whether we're going to offend some fundamentalist from Tulsa, Oklahoma."

JOHN FLETCHER, Professor of medical ethics, University of Virginia: "The idea of natural law is one that I think is not a viable concept when it comes to the gene pool … suppose we knew how to treat cystic fibrosis … and didn't do it because of the belief that people had a right to an untampered genetic patrimony…? It's just plain wrong. You violate one of the basic principles of morality, namely that you want to treat a person as you would want to be treated."

The problem of human identity is further complicated by an astonishing advance that occurred in 1997: cloning.

Towards Immortality

We cut to a veterinary hospital in Colorado. We see a cute kitten being examined by a scientist in sterile garb. Nearby is a larger cat with the same fur color.

Since 1997, scientists have been able to do something else that has never before happened in nature (with the special exception of identical twins)—cloning. Lucy looks like any normal kitten. But Lucy is, in fact, a clone. She was made by taking a skin cell from an adult cat. The nucleus of that cell—which had become specialized to make only skin cells—was, through a piece of scientific magic, "reset" to its embryonic state (when it had the potential to make any of the hundreds of kinds of cell types that compose a cat), injected into an egg, and implanted. Lucy is the result. Lucy has no mother and father; she was born by asexual reproduction. She is a genetic copy of the cat that provided the skin cell nucleus. Lucy is an evolutionary freak.

In the past five years, dozens of animals have been cloned, and despite the fact that many nations have officially "banned" human cloning, several private groups have announced their intention to try to clone a human being. Most experts do not expect them to succeed any time soon, and, even if they do, it is thought that human cloning is unlikely to be a common practice, due to the enormous uncertainties involved in the procedure. But Leon Kass feels that a fundamental taboo is at stake.

LEON KASS: "Even if human cloning is rarely undertaken, a society in which it is tolerated is no longer the same society—any more than a society that permits (even small-scale) incest or cannibalism or slavery. It is a society that has forgotten how to shudder, that always rationalizes away the abominable. … Should commer-

cial interests develop "nucleus banking," as they have sperm-banking; should famous athletes or other celebrities decide to market their DNA the way they now market their autographs … should all this come to pass, then cloning, if it is permitted, could become more than a marginal practice simply on the basis of free reproductive choice."

But other ethicists counter that there are legitimate reasons when human cloning might be sanctioned. For example, providing a child for an infertile couple, or replacing a beloved who is dying or dead, or, perhaps, permitting reproduction for homosexual men (who want no sexual involvement with the opposite sex) or infertile women who want to have a genetic connection with their offspring (like the case of the Janet M).

And what about securing a source of genetically identical organs for transplantation?

If you think this is unlikely, such cases have already occurred—even before cloning.

DANIEL CALLAGHAN: "Take the case of Molly Nash. Molly Nash was born with Fanconi anemia, a lethal blood disorder. When Molly's parents decided to have a second child with the help of PGD, they obviously wanted that child to be free of anemia. But they wanted something else as well. They wanted to select an embryo that would also be a blood donor for their daughter Molly—one that was HLA (human leukocyte antigen) compatible with Molly. At first blush, this case might appear to violate Immanuel Kant's famous dictum that a person should never be treated solely as a means, but always also as an end in himself or herself."

Cloning, however, opens up new possibilities. Some critics find the idea of reproduction without sex deeply disturbing. Nature, they argue, never intended mammals to reproduce this way.

LEON KASS: "Sexual reproduction is the natural way of all mammalian reproduction. By nature, each child has two complementary biological progenitors … cloning threatens confusion of identity and individuality People recoil from the prospect of mass production of human beings, with large clones of look-alikes … the idea of father-son or mother-daughter twins, the bizarre prospects of a woman giving birth to and rearing a genetic copy of herself, her spouse, or even her deceased mother; the grotesqueness of replacing a child as an exact replacement for another who has died; the utilitarian creation of embryonic duplicates of oneself, to be frozen away or created when necessary, in case of need of homologous tissue or organs for transplantation; the narcissism of those who would clone themselves."

Some scientific researchers protest that critics like Kass are missing the point. The advance of cloning signaled not a new means of making identical-looking human clones, but a radically new approach to medicine—something far too important to be derailed by emotion.

Cloning, according to scientists, has never been about copying humans; it has been about finding new ways of curing the sick. Since Dolly was cloned, for example, researchers have been able to create herds of cows that produce human insulin, interferon, and other drugs in their milk. Now that these animals can be cloned, there is a whole new way to produce pure pharmaceuticals. And linked to cloning research is the fast-moving field of stem cells—cells that can become any sort of tissue in the body—and the promise of new livers, hearts, and eyes for anyone who needs them.

We are in a small clinical laboratory. A young woman in a white coat is holding what look like two long steel needles, one in each hand. She is using them to manipulate something on a tiny microscope slide. Next to the microscope is a television monitor that shows what she's doing. On the monitor is a cluster of round transparent cells. As we watch, the woman uses a tiny vacuum—giant on the screen—to choose a cell and hold it steady. Then she punctures it with a tiny needle, sucks out the DNA inside, and shoots it into another cell. As we watch, she makes short work of ten cells, then pulls another cluster into view. The work is rhythmical and routine.

Every cell in a human body has a full complement of DNA—eye cells have the same DNA as muscle cells—but in all specialized cells, most of the DNA is silent; most of the genes are turned off. Only the genes necessary for a particular cell (for example, skin genes) are "expressed." It wasn't always that way. At the start of life, when an organism is an eight-celled embryo, each of the eight cells has the potential to become any cell in the body. These totipotent stem cells then start to take on definite fates. As they divide and divide, the cells become specialized and lose their "plasticity"—ending up as either a muscle cell or a skin cell or one of the several hundred other cell types in the mammalian body.

The miracle of embryogenesis is that cells magically self-assemble into the myriad tissues of the body by means of positional information mediated by chemical signals. When an organ or limb has reached its determined size it "knows" to stop growing.

Once mammals are fully grown, few cell types retain the ability to regrow. But there are exceptions. Some cell

types—notably blood, stomach, and skin—retain the capacity for repair. And each has a source of stem cells that helps generate replacement cells while maintaining correct numbers. But for the most part, humans cannot regenerate much, so a badly ravaged heart that can't be patched up is doomed. If we could find a source of stem cells and place them in other parts of the body, then those stem cells might heal damaged organs. This is the dream of regenerative medicine.

Before Dolly, many scientists doubted that ordinary specialized cells could be converted to embryonic stem cells, but the cloning of Dolly showed that, in principle, the mature fate could be reprogrammed to that of its embryonic state. Stem cells are the Holy Grail of biology, and scientists don't want the fear of cloning to stand in their way. They even use a distinct term for it: therapeutic cloning.

GREGORY STOCK: "As opposed to the cloning of individuals, this so-called "therapeutic cloning" seeks only to create a new medical tool. This scheme takes a nucleus from a patient's skin cell and inserts it into a human egg grown in a dish. Its inner cell mass is then removed and cultivated until there are enough stem cells to repair whatever tissue in the patient needs it."

Therapeutic cloning has not so far been done in humans, but scientists are very excited about using stem cells for regenerative medicine from other sources. One source for embryonic stem cells is discarded embryos from *in vitro* fertilization clinics. A less controversial source of stem cells is the adult body, which possesses some kinds of stem cells in the bone marrow, for example. Osiris, a company named after the Egyptian god of regeneration, is hard at work testing so-called adult stem cells to see what tissue they can be made to grow into. They have discovered that even these adult stem cells may be pluripotent and capable of regenerating more than one type of tissue. What they have found is that the stem cells seem to take their signal from their situation and the surrounding cells and then "decide" what kinds of cells to become. Mesenchymal cells, for example, will in different settings form bone, cartilage, and stroma.

Ronald McKay, of the National Institutes of Health, believes we are on the verge of revolution.

RONALD MCKAY: "The body is designed as a self-assembling system. Given the right cues, cells will organize themselves into the tissue or structure appropriate for that position in the body. It is a society of cell types, all communicating. In two years, people will routinely be reconstituting liver, regenerating heart, routinely building pancreatic islets, routinely putting cells into the brain that get incorporated into the normal circuitry. They will routinely be rebuilding all tissues."

Bill Haseltine, of Human Genome Sciences, believes that stem cells, together with the fruits of the Human Genome Project, form part of a new type of medicine called *regenerative medicine*—one that will totally transform the prospects of the human species.

BILL HASELTINE: "I believe our generation is the first to map a possible route to individual immortality. When we know, in effect, what our cells know, health care will be revolutionized, giving birth to regenerative medicine—ultimately including the prolongation of life by regenerating our aging bodies with younger cells."

What's Wrong with Living Longer?

If regenerative medicine bears fruit, it may contribute yet another challenge to our notion of humanness: our mortality. By counteracting the major degenerative diseases—Alzheimer's, Parkinson's, connective tissue disease, diabetes, heart disease, cancer—it may allow humans to live considerably better and considerably longer. Is this is a good thing? Not necessarily.

LEON KASS: "The finitude of human life is a blessing for every individual, whether he knows it or not."

Human life has traditionally been designed around a cycle of birth, procreation, and death. If people start living too long, this might change society profoundly. In 1825, British actuary Benjamin Gompertz came up with a rule that, until recently, has held true. After puberty, Gompertz calculated, the human death rate doubles every eight years. But over the 20th century the Gompertz rule has been apparently defied, at least in developed countries. It's not just that life expectancy has risen. At the start of the 20th century an American woman's life expectancy was 46 years; today it is 79. It also seems that if you make it to 75 years old, your chances of dying actually start to decelerate (in clear violation of the Gompertz rule). This is evidenced by the fact that the maximum life span, as measured by the number of people who live more than 100 years, has risen rapidly. It is customary for the Queen of England to send a birthday telegram to every Briton who is over 100 years old. When Queen Elizabeth acceded to the throne in 1952, only 255 telegrams were sent. In 1996, the Queen, herself now over 80, dispatched 5,218 messages.

So, how much longer can we expect to live? Regenerative medicine may extend lives by a few decades. Even that would be problematic for a society. But some scientists argue that one day we will be able go further and genetically engineer significant increases in longevity.

All life is made up of cells. But the life spans of living organisms vary greatly—from round worms that live a few days to Joshua trees that live for 5,000 years. Evolution has been able to adjust different organisms' life spans to suit various competing survival needs. Can scientists do the same? With animals the answer is a definite *yes*. Scientists have been able to increase the life span of round worms by a factor of six with very simple genetic manipulations. If the same things could be done for humans, we might live for 500 years or more.

But just because we *might* be able to do it, *should* we?

We return to the clinic in Lancaster County. Miriam and John Martin wake Marsha up and she gets ready to leave with her parents and siblings.

The risks of biotechnology depend on how much a person needs it. Miriam and John Martin can hardly wait for Dr. Blaese to develop a method to correct their children's genetic curse.

We see John and Mary Thompson having a conversation with their doctor at an IV clinic.

John and Mary Thompson want to take advantage of the choices that the new technology offers them as well. They want to be sure that their child is born deaf, not hearing.

Over the next thousand years, we can expect major changes that will make the story of the Martins and the Thompsons seem like sideshows. We can expect the separation of the procreational and recreational purposes of sex.

Within a few decades the results of the Human Genome Project will start to pay dividends. The identification of all the genes in the genome will permit preimplantation genetic diagnosis both for disease traits and for nonmedical "enhancing" traits. Soon afterwards, we may see the advent of human germline engineering, including the adding of special artificial chromosome pairs (some of the genes of which could be activated when desired). Simultaneously, the widespread ability to clone adult cells will make possible a revolution in regenerative medicine, enabling humans to live better and longer. Finally, there is the possibility that life spans will be extended to half a millennium. Some of these things will happen sooner than others. Some may take hundreds of years to come into widespread use.

What will it mean to have a society in which parents compete to give their children every genetic advantage possible? What will it mean to have a society where people live long enough to "parent" 12 generations? What will the balance be between childhood, working life, and retirement? How will resources be shared? And will all cultures have the same enthusiasm for these biotechnological options? Currently, the greatest opposition to biotechnology can be found in Germany (perhaps because of the association with Nazi eugenics), and the support for genetic engineering is found in Asian cultures.[1]

LEON KASS: "Repugnance, here as elsewhere, revolts against the excess of human willfulness, warning us not to transgress what is unspeakably profound. Shallow are the souls who have forgotten how to shudder."

STEVEN PINKER: "There may be good arguments against human cloning, but the shudder test is not one of them. People have shuddered at all kinds of morally irrelevant violations of purity in their culture: touching an untouchable, drinking from the same water fountain as a person of color, allowing Jewish blood to mix with Aryan blood, tolerating sodomy between consenting men. As recently as 1978, many people (including Kass) shuddered at the new technology of *in vitro* fertilization, or, as it was then called, "test tube babies." But now it is morally unexceptionable and, for hundreds of thousands of people, a source of immeasurable happiness of life itself."

The Longer-Term Future

But looking further into the future, there is more at stake than equality and human nature. The mysteries of human consciousness, human dignity, and free will are also under scrutiny, thanks to developments in computer science and robotics.

Gary Kasparov playing chess with Deep Blue, an IBM computer.

In 1997, a specially programmed IBM computer called Deep Blue played chess with the world champion, Gary Kasparov, and beat him with ease. The event was a

1. As Fukuyama puts it: "Asia lacks a revealed system of religion that originates from a transcendental deity. Confucianism lacks any concept of God, folk religions like Taoism and Shinto tend not to make such a sharp distinction between mankind and the rest of natural creation."

This may explain the proclivity of this part of the world for genetic interventions. In China, over and above their one-child policy, the evidence is that Chinese genetic counselors give very different advice from Western counselors, being much more likely to suggest abortion. One study found that counselors in China recommended abortion for Klinefelter Syndrome (a common form of dwarfism) 92 percent of the time, whereas US counselors made that recommendation only ten percent of the time.

benchmark in the tumultuous history of artificial intelligence. The game of chess was so complicated that many doubted that a computer would be able to beat the finest player the world had ever seen. But they were wrong.

AI began some 50 years ago and it has provided some of the keenest insights into what is special about humanity.

MARVIN MINSKY: "When we started trying to represent human intelligence in computers back in the '50s, we thought that what would be hard to do were the things that humans found hard—math, chess, symbolic reasoning. Surprisingly, the hard things were easy. By the early '60s we had programs that could get an A on an MIT calculus paper. On the other hand, the things we thought were easy were unbelievably hard. Getting a computer to use natural language remains very hard and getting a robot to stack blocks or navigate a room like a three-year-old was practically impossible. I remember an early effort to get a machine to build a tower of blocks. The machine picked up a block, lifted it into the air, and dropped it. We realized after a while what was going on. It was trying to build the tower from the top down. It didn't know about gravity."

One of the harshest critics of AI was an MIT philosopher named Hubert Dreyfus. He built a career challenging the claims of AI. He even challenged an early computer program to a chess match and lost.

HUBERT DREYFUS: "So they have made pretty good chess-playing machines—so what!! I think that they haven't answered the main challenges—that machines lacking live bodies don't have feelings, intentions, goals. Not knowing what it is to be human, they cannot ever hope to duplicate human features. On the other hand, I have been astonished by what they have been able to achieve with trickery and speed. Deep Blue doesn't play chess like Kasparov; it uses a crude brute force method of analyzing billions and billions of moves. On the other hand, the result is that Deep Blue can play a stunning game of chess. The thing to remember is that Kasparov can do many other things."

AI Laboratory, MIT, Rodney Brooks's laboratory.

In the future, ethicists, philosophers, and theologians will not only have to deal with genetic engineers, they must also deal with roboticists like Rodney Brooks. From the time he was a child, Brooks has always wanted to build robots. But his early attempts to get them to navigate a room showed how "difficult" this apparently easy task was for a machine. Despite being connected to the fastest computers then around, it took the early CART robot six hours to get across a small room, avoiding objects en route. Brooks decided that roboticists were taking the wrong approach.

RODNEY BROOKS: "Rather than connect a machine with a cable to a powerful computer that reasoned, I decided to try to build a simpler robot—a spider—and embody everything in the onboard spider senses and processing. Rather than trying to represent the problem the spider faced in terms of higher thinking—geometry, planning, path selection, etc.—I tried to come up with some simple rules that would enable it to survive in its environment. I gave the spider what it needed to make quick decisions in order to avoid or move towards certain objects. One simple idea was that instead of telling it to avoid objects, I said, 'Just go for the spaces between objects.'"

Brooks's robots can carry out surprisingly complex behavior based on a few simple rules. But this may be eclipsed by what is to come. A robot dog is now within reach. And in the future, who knows?

RODNEY BROOKS: "Within 20 years, our computers will be a thousand times more powerful than they are now. The amount of computational power in a personal computer will surpass that in a human brain sometime in the next 20 years. When this happens, we may see some surprising things. Even if our machines don't work the same way that we biological machines work, they may be able to pull off a task so well that we can't tell the difference."

HUBERT DREYFUS: "Robots will never be able to feel emotions; they will never be able to feel pain, hunger, and pleasure the way a person does. They didn't evolve with the passion to seek out their own kind and love, hate, and nurture … they don't come equipped with the drive to survive."

But Brooks cautions that humanists should not underestimate technology.

RODNEY BROOKS: "Emotions are our current last bastion of specialness. Computers are not only able to calculate better than humans, but do many tasks better than humans. Computers are now better at doing symbolic algebra than are humans. We many have lost our central location in the universe; we may have lost our unique creation heritage … we may have been beaten out by machines in pure calculating and reason, but we still have our emotions. This is what makes us special. Machines do not have them, and we alone do."

Fellow roboticist Hans Moravec thinks that the advent of intelligent robots will represent a pivotal point in human culture, much like the advent of writing, computers, or the internet.

HANS MORAVEC: "The first intelligent computers will provide us with unimaginable wealth brought on by the fantastic levels of productivity. By 2020 there is a technological singularity that enables us to move ahead very fast with the help of robots."

And beyond that, Moravec sees robots as our path to immortality. Sometime in the future, he believes, we will possess the technology to download human consciousness—the contents of a human brain—into a machine. Robots become our Mind Children, enabling us to transcend our biological fragility.

Others see humans fusing with machine technology, either becoming "cyborgs," in which hardware is internally located (implanted organs and joints, brain chips), or "fyborgs," where the technology is kept on the periphery or outside the body (glasses, hearing aids, telephones). Cyborgs are legion in science fiction: for example, *Terminator*, or *Six Billion Dollar Man*, or *Blade Runner.*

Out of an elevator walks Hugh Herr. From the thighs up, he is all human; from the thighs down, he is all robot.

Hugh is a double-leg amputee. He is working to develop human-machine interfaces that will enable him to walk. Currently his mechanical legs are cumbersome. He wants to grow muscle instead of using electromechanical muscles. He thinks biological tissue may have distinct advantages.

The fusion of silicon and carbon-based life forms is currently being attempted in laboratories. A silicon chip with holes in it is implanted right in the path of a severed cluster of nerve cells. The nerves regrow through the hole, and the chip can both measure electrical activities in the nerves and inject signals into them.

Immediate applications will include artificial arms, but this will be just the beginning. What about implanting chips into the brain? There have been some experiments in which patients have been able to move a mouse pointer just by thinking; the brain impulses are picked up and drive an external actuator.

Humans of the future—with infrared vision and muscle implants—may be technologically as well as biologically enhanced. One cyborgian, Ray Kurzweil, inventor of the Kurzweil Reading Machine, thinks the artificial part will one day predominate. He believes that "we will enhance our brains gradually through direct connection with machine intelligence until the essence of thinking has fully migrated to the far more capable and reliable machinery."

Such talk strikes many humanists and theologians as hubristic and exaggerated. Since Jews, Christians, and Muslims believe that humans are created in God's image, the idea of artificial intelligence is as unsettling as the idea of germline engineering. But many scientists think that, like it or not, it *will* happen.

GREGORY STOCK: "We are in the midst of an evolutionary transition as significant as that 700 million years ago when complex multi-cellular organisms evolved. Future humans will look back on this era (the next few hundred years) as one of the most extraordinary in the history of life, a period when the key developments that have shaped the form and character of their existence—genetic engineering, artificial intelligence, and space travel—took place."

Section V

Transcripts of the Workshop Discussion Sessions

"The Future Human" Workshop, held in Bellevue, WA, November 8–10, 2002, brought together nine prominent scientists and futurists to discuss where science and technology may take us as a species in the next thousand years. The explicit purpose of the discussions was to provide scientific content upon which story line and images may be constructed for the creation of a one-hour television program entitled "The Future Human."

Following are the transcripts of the discussion sessions, all of which were conducted with the full gathering of the nine scholars, plus the television series Executive Producer and a second producer from Palfreman Film Group, affiliates who have been involved in the early stages of planning for *The Next Thousand Years* television series, and Foundation officers and staff.

Introductory Session

Bob Citron: Good morning, everyone. I am Bob Citron, Executive Director of the Foundation For the Future. I would like to introduce Walter Kistler, who is the benefactor and President of the Foundation. Walter?

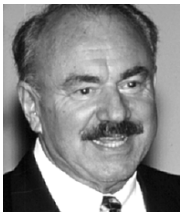
…when you look at the future of humanity, you should start with what is really the basis: the genes and memes, and how these may change.

Walter Kistler: Welcome. I hope you all had a good night in our nice Seattle area, with the beautiful colors of the foliage now.

Today should be a very important and very interesting meeting, as we talk about the future human being. I have the feeling that slowly some basic concepts are penetrating today's scientific, biological, sociological society, based on three simple things that were already known, I suspect, to the ancient Greeks and to the Romans. Number One is that society, of whatever kind, is built up by individual human beings. It will, therefore, reflect the average view, abilities, and so on of these human beings.

Number Two is that human beings themselves are pretty much determined by two things: by their genes (their genomes) and by their culture. We can say, "by genes and memes," to say it in simple words. Number Three: The lifetime of memes may sometimes be radically shortened or changed, as by revolutions, for example, the French Revolution. On the other hand, genes are very long-lived and permanent. The average lifetime of a gene is about three million years, I understand.

So, when you look at the future of humanity, you should start with what is really the basis: the genes and memes, and how these may change. I am convinced that our discussions today concerning the future human should be very interesting.



…we want to get a sense of the thinking of some of the brightest minds doing research in these fields about how humans might possibly evolve…

Bob Citron: Thank you, Walter. We will see two videos this morning to give you more insight about the Foundation For the Future and why Walter endowed it. The Foundation is endowed permanently, so we plan to be here for centuries. As I told Jon Palfreman last night when we were talking about the television series: The Foundation will be here a century from now; I am not sure PBS will be here.

In any event, the Foundation is delighted to have all of you here. I want to thank Sesh, from whom you will hear a lot in the next few days; Greg Stock, for putting together such an illustrious group of scholars; and Jon and Barbara, who are here to obtain as much information as possible from you and your different views to incorporate into a treatment and script for this program, which is now Program No. 5: "The Future Human."

As we will discuss in greater detail during the day, we don't want to *predict* what humans are going to be like in the future, but we want to get a sense of the thinking of some of the brightest minds doing research in these fields about how humans might possibly evolve in the next thousand years, genetically and nonbiologically.

I would like to start by showing a 15-minute video on the Foundation For the Future. We update this video about twice a year. It will give you a sense of the Foundation's activities.

[Video shown]

Bob Citron: You can see that we have half a dozen different programs going on. The premise of the Foundation is: Where does humanity go from here? This television series, which we are hoping to produce sometime over the next five years, is intended to reach a larger audience than the traditional audience we have, which is hundreds of scholars and thousands of classrooms around

the world where we distribute our materials. I want to thank David Rapka, who made that video.

Now we are going to show a five-minute interview with Greg Stock. We interview all of the scholars who participate. We have filmed perhaps a hundred scholars in five-minute interviews, and we asked them all the same question: What is your vision of the thousand-year future for humanity? Eventually all of those interviews will be on our website so that students, teachers, and scholars from all over the world will be able to access those video clips. But because Greg made such a succinct statement, his is the only interview we are going to show now. Greg hasn't seen this yet. We filmed it about two years ago.

…we are in the midst of an evolutionary breakthrough, a transition that is every bit as significant as that that occurred 700 million years ago…

[**Text of Video Interview of Gregory Stock**]: The interesting thing about picking a thousand years to look into the future is that it seems so long to us. It is mind-boggling to push even a hundred years into the future today. That is something that is an extraordinary difference between the present time and previous times in the history of humanity and the history of life. I believe that the reason for that is that we are in the midst of an evolutionary breakthrough, a transition that is every bit as significant as that that occurred 700 million years ago when single cells joined together to form multicellular organisms—because *we* are joining together by our technologies, by our communications technologies, by our trade, to produce a cooperative that is as intimately connected as are the cells in a multicellular organism.

When we think of the things that create our most human qualities, we tend to attribute them to ourselves, but they are really extracted from this larger entity. The fact that we can even envision the future, for instance, is not coming out of our individual concepts; it is extracted from all the information that is scattered and distributed around us—a sort of a global brain. The fact that we can detect global warming and realize that that exists and is occurring now does not come from individual experience. No individual can perceive a half a degree in global warming averaged over the surface of the planet. This comes from the cooperation of thousands, or tens or hundreds of thousands, of people and instruments, and all of this is melded together. The question is: What shape will we be in? I think that this enterprise is an extraordinarily robust one, and there is almost no chance that we will not be here. And the fundamental breakthroughs that are occurring now, which are unique to this time—in fact, they are without precedent in the history of life—are, first, that we are creating nonliving materials (silicon) and constructing it at a level that it is achieving the complexity of life itself. This is going to go on. In fact, intelligence will probably exceed that of human intelligence in noncarbon substrates. Nothing like this has ever happened before.

The second thing that is occurring is that we are beginning to manipulate our own biology consciously, so that we are basically seizing control over our own evolution, and we will radically transform ourselves.

The third is that we are moving out into space. For the first time in the history of life, life is escaping from this thin film on the surface of the planet and pushing out toward the stars.

…when future humans, in whatever shape they may be or whatever they may be, look back on this time, it will seem this extraordinarily turbulent, troubling moment that was also glorious…

These are the three things that are going to be the very foundation of the future. And when future humans, in whatever shape they may be or whatever they may be, look back on this time, it will seem this extraordinarily turbulent, troubling moment that was also glorious: that this was the moment when the foundation of the distant future was laid down, when these pillars were established. And we have the privilege to be alive at this instant in time of truly cosmic significance.

As to what the world will be like a thousand years from now, I really have very little idea, except that it will be radically different from the way it is. I suspect that humans themselves will be transformed beyond what would be recognizable today. And the main question we will be dealing with in the interim will be: What does it mean to be human? Basic questions of who we are and what we are: Those are the kinds of issues that will arise. These are the kinds of things we will be dealing with as we learn to live in a world where we are surrounded by hyperintelligent, inorganic materials, where we are transforming ourselves, where we are becoming hybridized, in some sense, with nonliving materials, where we are modifying our biology. There will be very, very fundamental changes. Although the world, as it is transformed, may be one that is so radically different that I would be extremely unhappy and uncomfortable in it, in the same way that our great-grandparents would be

uncomfortable in this world that we live in now, which I absolutely adore, I suspect that our future descendants, whatever they may be, are going to find it absolutely wonderful and will look back on this period as something so barbarous that they wonder how we could tolerate it.

Bob Citron: Before we go ahead into this morning's proceedings, I want to say one thing about the scholars vis-à-vis the film production. The filmmakers want to get as much insight into current thinking about the future of humans as possible for the film, but we don't want to have the scholars telling the filmmakers how to make the film. This is an important distinction between your role and that of the filmmakers who want to make an entertaining and educational film for a mass audience on PBS. The whole idea here is not to focus on the film, but to focus on your sense of where humans will be evolving during the next thousand years. Let the filmmakers capture what they wish to incorporate into the treatment for the film.

At this point, I am going to turn the meeting over to Sesh, who will explain what our plans are for the two days. Sesh is Deputy Director of the Foundation, in charge of programs.

Velamoor: Thank you, Bob. Let's get going. I would like each of you participants, starting with Jon, to take a minute to introduce yourself to the rest of the group.

…there has never been a project remotely resembling this one in the history of television.

Palfreman: I am Jon Palfreman. I am a television producer, originally from England, from the BBC. I worked for a long time with WBGH in Boston. I have been living in the States for about 13 years and have made lots and lots of films on science and public affairs, but, as I will be describing later, there has never been a project remotely resembling this one in the history of television.

I am here with my colleague, Barbara Moran; we are based in the Boston area. We are very excited about this project.

For me, the conversation began when Dolly was introduced to the world in 1997.

Fowler: I am Greg Fowler, the founder and Executive Director of Geneforum, a nonprofit organization that was birthed in the state of Oregon in 1999. I, too, am very pleased to be part of this discussion. I think it is an extremely important venture and adventure.

For me, the conversation began when Dolly was introduced to the world in 1997. I was at an AAAS symposium in Washington, DC, and Ian Wilmut, the genetic "father," the creator, of Dolly was introducing the concept of nuclear transplantation to the audience. He made a statement at that time that captured my enthusiasm for founding, ultimately, Geneforum, and that was: "We as a society need to decide how this technology will be used." I asked the panel of worthies later during the discussion period what they thought might be strategies for determining how society should decide what it wants to do with this particular technology of cloning. It was amazing to me—and revealing—that no one had any ideas. It was then that I decided that there needed to be a gene forum; there needed to be some organization that is working diligently to establish strategies for getting the public educated, for engaging the public, and for sharing public values with the policy process.

That is where we are at this particular time: beginning that process. And I see this participation today as a considerable step forward in that direction.

…I am Chair of a conference that will be held next June [2003] on transhumanist bioethics…

Hughes: My name is J. Hughes. I am a medical sociologist. I used to teach at the University of Chicago, at the Center for Clinical Medical Ethics there. I currently teach health policy at Trinity College in Hartford, Connecticut. I produce a radio show called Changesurfer Radio, which is about futurism and the politics of future technology. I also serve as the Secretary of the World Transhumanist Association, which is an organization

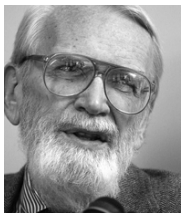
devoted to encouraging the use of technology to overcome the limitations of the human body. In that capacity, I am Chair of a conference that will be held next June [2003] on transhumanist bioethics, at which Greg Stock, Greg Pence, and some other bioethicists will be speaking. So, I am very excited about this particular topic. My current writing project is a book called *Cyborg Democracy*, which is about the impact of democracy on enhancement technologies and of enhancement technologies on democracy.

I am interested especially in long-term evolution and progressive evolution…in how complex the actual process of evolution is…

Campbell: I am John Campbell from the University of California in the Department of Neurobiology. I study theoretical genetics and the theory of evolution. I am interested especially in long-term evolution and progressive evolution. Most evolutionists try to think of the simplest model that can be made to explain the evolutionary process. My take is that evolution must be a very complex process, so I am interested in how complex the actual process of evolution is, instead of how simplistic a model one can build for it.

I am right in the middle of trying to develop new technology for genetic engineering and proteomic analysis of humans.

Anderson: I am French Anderson. I am right in the middle of trying to develop new technology for genetic engineering and proteomic analysis of humans. My position is Professor of biochemistry and pediatrics at USC Keck School of Medicine and Director of Gene Therapy Laboratories there.



I am a consulting futurist …interested in everything.

Coates: I am Joe Coates. I am a consulting futurist, and I am interested in everything.

I am interested in the basic biochemical and genetic mechanisms that underlie intelligence in organisms ranging from bacteria to humans.

Jeffry Stock: I am Jeff Stock, Greg's brother, and I am a Professor of microbiology and chemistry at Princeton University. I am interested in the basic biochemical and genetic mechanisms that underlie intelligence in organisms ranging from bacteria to humans.

Over the past 25 years, I have been involved in a variety of topics in bioethics, especially concerning such matters as human genetic engineering.

Zimmerman: I am Burke Zimmerman. I am a biophysicist by early training, but I have gone through my own personal evolution as an academic scientist, in policy positions in Washington, in biotech—most recently having founded an entrepreneurial company in Europe to develop cutting-edge vaccines. Over the past 25 years, I have been involved in a variety of topics in bioethics, especially concerning such matters as human genetic engineering. Probably the reason I am here stems from a year that I spent at UCSF in the mid-1980s with Greg Fowler, Eric Juengst, and Al Johnson exploring the whole idea of human germline genetic engineering. A number of publications have come from that project. It is a fascinating topic and certainly will be a major part of the discussion of this conference.

…although our genes define us as a species, our neurons define us as individuals…and the wiring happens after birth, almost exclusively.

Andreadis: My name is Athena Andreadis. I am an academic scientist, a molecular biologist, but my major interests always have been the human exploration of space and how the brain creates the mind, which is known as "the binding problem." I think it is the holy grail of science.

Although I am a hard-core geneticist on the bench, I think these controversies will become inevitable when we go into the question of self-designed evolution for humans, and some of the controversies might be laid to rest when people realize that although our genes define us as a species, our neurons define us as individuals. We are who we are from the neck up, and the wiring happens after birth, almost exclusively. If people knew this, I think a lot of the repugnance and controversy would die down, and we wouldn't be having meetings like this.

To integrate all these interests, I also write popular science books. This is how I came to be invited to this conference. I don't think that as a straight molecular biologist I would be of interest to this gathering. I am looking forward to this.

It is important to think…about what our ability is to influence the possible trajectories of humanity…

Gregory Stock: I am Greg Stock. I direct the Program on Medicine, Technology, and Society at UCLA, and I constantly think about the ways technologies are going to shape us in various dimensions. It is important to think about these things and to think also about what our ability is to influence the possible trajectories of humanity and the extent to which our future simply emerges out of the chaos of developments occurring today. It is great to have a group get together to talk about these things.

Velamoor: Thank you. Walter, do you want to comment before we begin the discussions?

Walter Kistler: I might just say a couple of words about why I started this Foundation after being reasonably successful in business. I made some money and thought: My kids can make their own money; they are able enough. I wanted to do something of permanence. The reason I also felt quite strongly about doing something like this Foundation is that environmentalists, 30 or 40 years ago, made us begin to worry about our environment, to realize that we have been destroying or polluting our environment—with the best of intentions—in the prior decades. My feeling was that we do just about the same thing with our human genome: Nobody cares how it changes, how it gets polluted or degraded. I thought that I would establish a Foundation that would help people become aware that there are dangers—as well as new opportunities, no doubt, fortunately. I think right now the human genome is going down the drain fairly fast. What millions of years built up, we now build down, with the best of intentions, exactly like we polluted our planet with the best of intentions a hundred years ago.

Velamoor: Thank you, Walter. Let's go ahead now with the workshop.

Review of Preliminary Outline

In this discussion session, the participants reviewed the preliminary outline for the program to determine the best approach for providing useful input on how scientific and technological developments may alter humanity over the next thousand years.

Facilitator: Sesh Velamoor

What has it meant to be human?
What does it mean to be human?
And what will it mean to be human?

Velamoor: I would like to get going by taking a minute to explain what this workshop is about, why we are doing it, and what we hope to accomplish. Quite a bit has been said about that fact that we are in the process of developing a multi-part television series. An important episode in that series is "The Future Human." Jon Palfreman and his associates developed a preliminary treatment for this episode, and that treatment will be revised and adjusted as a result of the input from our discussions.

In planning this workshop, we wanted to bring together expertise in three different sets: In the first set the expertise is in the technology, in the actual workings related to biological intervention, whether it is engineering, or at the germ level, or whatever it might be. Those people are here to speak to the possibilities for biological transformations.

The second aspect of the workshop is to commingle with the technological possibilities all the complexities that arise related to the question: "What does it mean to be human?" That question might be in three parts: What has it meant to be human? What does it mean to be human? And what *will* it mean to be human? We want to explore that question in terms of identity and relationships among humans in the far future as well as what kinds of transitions will take place—or will it remain the same? Associated with that, we want to consider the complexities related to the ethical, the moral, the legal questions that are already coming to the fore. Burke Zimmerman has written about the limits: Where do we stop? Are there limits? Should there be limits?

The third part is: If we knew the first and the second parts, how might all this unfold? Will it be according to the market mechanism, as Greg Stock talked about in his book? Or will it be something that will have to be legislated at a global level? Or will each country or each group of people evolve a process of their own?

Our focus is not just the content—the answers or the speculations about these three areas—but how we can translate that into material that Jon can use to enhance the treatment that will be the basis for what is dramatized on the television screen. Please keep that in the back of your minds throughout the workshop. There needs to be a coming together of the drama and the capturing of the images with the technology and the questions. I know it is a tall order, but I am sure, with the minds in this room, that we will make some very good progress.

Jon, will you go ahead and put forward the treatment you have in mind?

Usually when television takes on sweeping intellectual territory, it starts at a point where the content has been defined.

Palfreman: For those of you who are new to the Foundation For the Future, I am sure you are feeling a mixture of intrigue with a slight bit of discomfort about whether or not this is a legitimate enterprise. This Foundation is a very interesting and singular thing. My own introduction to it was when I was asked, through a colleague at Tufts University, to help the Foundation make a film covering the span from the Big Bang to the future of humanity in 14 minutes. We did that, and the film is called *Cosmic Origins*. That was my introduction

to the way this Foundation thinks. As you spend more time, you will accept this as a legitimate, good-faith effort, but one that is so new that it is very difficult to clarify what is being spoken about. In general terms, it is easy to state what the mission of the Foundation is concerning this long-range vision of humanity. When you start to try to think about turning it into a television series, it becomes quite complicated.

I will say a few words first about television and some of the constraints. Television is a very powerful medium, but it is used mostly for rather unimportant things. It is under tremendous commercial pressures, and it follows fads and appetites, so we have series like *Survivor*, *Fear Factor*, and *American Idol*. But it has also, throughout its history, been used on occasions to accomplish some extraordinary pieces of work, covering intimate portraits of modern wars, covering sweeping intellectual voyages in science and in the arts. We can all remember the landmark cases of *Cosmos*, *The Ascent of Man*, *The Story of English*, and so forth.

Television has the power to expose a much larger audience to an experience and ideas that, for the most part, are confined to just a few hundred people, in dusty books, or in conferences. But here is the distinction: Usually when television takes on sweeping intellectual territory, it starts at a point where the content has been defined. Sometimes the series may be based on a book that some author has spent years putting together. Daniel Yergin's book *The Prize*, about the story of oil—he had already done that work. *The Story of English* is another example. The author had already mapped out the content. At that stage, a television producer came in and helped to translate this vision, this content, into television.

This project isn't at all like other television ventures, because almost never does it happen like this, where the content of the series has not been mapped out. In this case, it is describable in very general, very vague terms, but when you get beyond that, it very hard to do, so this is truly unique in that sense.

If you look at the history of the Foundation, the first major activity was these workshops. If you have read some of the transcripts, what is very positive is that they are tremendously inclusive, wide-ranging discussions that allow people to bring in scientific, technological, economic, ethical, religious issues; Eastern philosophy; Western philosophy—it is enormously inclusive. But it is also maddeningly unresolved. If you look at these conversations, some are inspiring; some just thrash about wildly with every scholar bashing on his own agenda. I think that is a very good first phase. But once you decide to do something like a television series, or write a book, or do anything that is a work of art where you have to contain and shape these ideas, you enter another phase, because you have to choose. You have to exclude. You have to elevate some themes and reduce some other themes. And this starts to get more conflicted, and not everyone is going to be happy, but this is the stage where we are.

When I first heard about the series from Bob [Citron], I was intrigued, but I was also a bit skeptical, and I think that was the view of most of my television colleagues when I asked them to participate in the workshop earlier this year. The first story outlines could not really have been more vague; they were the titles of episodes with book lists and scholar lists, and nothing really fleshed out. I don't see that it could have been any other way, but it meant taking an awful lot on faith.

…the intellectual territory is so vast…it is really not possible for any one mind to do the whole thing.

Clearly, to move forward, to go to any sort of funding agency, to make it even worthwhile to bring in television producers, you have to get to a stage where the content of some of these episodes is mapped out, where you can distinguish episode from episode. In the early stages there is a tremendous amount of overlap, and the intellectual territory is so vast, ranging from cosmology, philosophical thought, biochemistry, astrophysics—it is really not possible for any one mind to do the whole thing. You have to carve it out into smaller chunks so that normal minds can make progress.

Earlier this year we held a workshop where we brought some of the greatest television producers in the world—science producers, mostly—to Seattle to talk about this. In retrospect, this seems to me a premature thing to have done, given what I have just been saying about the content not being mapped out. But it did, I think, bring home a certain realism to the project. Television producers are just as arrogant and outspoken as scholars are. Actually having them all in the same room was quite an interesting process.

Two highlights of the meeting were the content part: Greg Stock's talk on "Redesigning Humans" and Peter Ward's talk, "Future Evolution." They actually gave content, and the producers could start to think about how they would turn it into programs. Much of the rest of

the weekend was concerned with form. It is very natural: People prefer to talk about form rather than content because they can just make it up as they go along. However, it is ultimately largely abstract. The producers were trying to come up with ways in which they would do this, but they didn't have a very good idea of what would be in the episodes. So, I think it was of limited value in that sense, but it was clear to me, after that, that we needed to get to a stage where we could start talking in detail, conceptualizing some of the episodes.

The problem was that there wasn't very good funding in place to do that. This was a classic cart-before-the-horse problem. In applications for grants, funders really want to know what things are about, and it is very difficult to apply for money to figure out what you are going to be doing. That is, nevertheless, where we were this year when a little bit of funding became available to explore one of the episodes, which is "The Future Human," which has always been the one easiest to separate from the others.

The way this particular proposal came about is quite special. Anna Jhirad has been applying for a grant from the National Endowment for the Humanities. This is a grant to help a person write a proposal. The way things work now in this competitive fundraising is that in order to get a grant to write a proposal, you have to write a proposal. It is circular in that sense.

Andreadis: All grants are like that.

…the world is populated by people for whom these ideas are quite new, quite threatening, quite novel…

Palfreman: Yes. Because this was the National Endowment for the Humanities, there was pressure to approach this in a slightly different way than one would naturally if one were going for a National Science Foundation grant—to try to skew it more to humanities approaches, to try to make it more appealing. That was quite helpful, because when one thinks of potential audiences for this, one needs to take into account the fact that the world is populated by people for whom these ideas are quite new, quite threatening, quite novel—but they might connect at other levels if one approaches it philosophically, religiously, spiritually, and so forth. It was interesting to go at it in that sense.

The essence of what I want to say is that in television, as in most art forms, form should follow content. It is very easy to talk about form, but in general most of the forms in literature, television, and movies have not changed much since the time of the Greeks. They are really pretty much the same, but the content obviously changes, and the best way to do something should flow from what it is about.

The phase we need to go through is, first of all, to map out the intellectual territory: to find out what are the most interesting arguments, the most compelling examples, the best conceptualizations. Let these things fight it out to see which is really the most interesting and most appealing, and end up with an essay that, if anybody read it, he would say: "Wow! This is pretty good." Greg Stock's five-minute interview was terrific like that. It drew you in and got you to think about these things. When we reach that stage, that is the time when a television producer can come in and grapple with these enormous problems and how to turn this into television. This is very problematic because you are talking, for the most part, about future things that haven't happened. It is going to be hard—but it is going to be impossible unless we map out what it is about in advance.

Now, the proposal that is in your notebooks was developed just to support the NEH grant. I threw in, as you can see, pretty much everything but the kitchen sink. There is germline engineering, preimplantation genetic diagnosis, individualized genomics, gene identification, genetic screening, cloning, therapeutic cloning, stem cells, artificial chromosomes, regenerative medicine, issues of longevity, artificial intelligence, robotics, cyborgs, and an implication of modern technology. There is already a lot in there—way too much to fit into a documentary—but you may object to the examples, to the way it is done. Everything is open. What I and my colleague, Barbara, are trying to get at today is just to hear lots of content—not to talk too much about the form or the way to do it. That is premature.

My suggestion about how to organize these discussion groups is that one could take time scales. One group could look at the ten- to 20-year future; the second could look at the 20- to 100-year future; and the third could look at the long-term future, 100 to a thousand years. We need some way to organize these discussions so they won't be too similar to each other.

You may feel that the proposal here is too conventional. It is conventional partly because if you are applying to a funding organization, the only way they can connect to things is through the present. The process somewhat demands conventionality, but you may feel that it doesn't go out far enough. I would also be interested to hear whether you feel that issues to do with artificial intelligence and robotics belong in the same episode as something to do with the biology and genet-

ics of future humans. I would also be interested to know whether you feel that we should go into the past and explore the history of reproductive medicine as a way of giving us context.

We have some great minds in the room. I just want to hear a lot of content. Please feel free to criticize anything. Out of what we hear today, we will turn the treatment into something nearer, we hope, to the eventual program. And remember that this is just one out of several episodes. We don't have a consensus yet … I think we are moving as a group from thinking that this will go out first as a whole series to thinking that we might bring out episodes periodically. You can see that it is enormously difficult, but the aim is to make this seem less vague and open-ended to something more grounded so that it seems credible, reasonable, achievable, and worth supporting.

Looking at the treatment as it stands now, it deals with a lot of concepts. It uses examples. It is fairly conventional for this sort of document. We have germline engineering issues, which are introduced through an example of the treatment of an Amish with a rare genetic disease; preimplantation genetic diagnosis, which is introduced through an ethical dilemma that I think is rather interesting: a deaf couple want to have a deaf child. Very often we as a society focus on the utilitarian benefit of a specific medical procedure, and it is incremental. That is quite an interesting one and most people feel a little bit uncomfortable when they are presented with it. I would be very interested if you could think of future dilemmas. It brings the subject home to people when they have to wrestle with dilemmas. The deaf issue is interesting because it deals with a choice. This couple feels that deafness is a gift, not a disability; therefore, they want a deaf child, whereas most people would feel that deafness is a disability. It seems to disrupt the sense of order that the purpose of genetic screening is to eliminate bad genes.

The notion of individualized genomics: As Greg has indicated, Celera and others are planning (or claim they are) to offer very quick genetic scans. You can challenge the issue about whether this is real now and the idea of, if you did have this now, where would it lead? Remember that we have a long time frame here. Maybe the idea is half-baked in ten years or 20 years, but it may be something we will clearly have to deal with long term.

What is it going to mean when we start getting interplay between artificial intelligence…and the ability to transform our genetics?

Gregory Stock: I think we have all read the treatment, but there is a larger issue that would be important to look at. You brought up the challenge of content and the scope of the treatment, and also that the purpose of this document was to seek a grant from the National Endowment for Humanities. Stepping back from what the purpose was for this particular treatment, the issue that comes to my mind is: Here we have a title—this is for the next thousand years—and yet because you are forced to find gripping, immediate content, it is a little bit in the future and a little bit in the past. We don't come to grips with the most challenging issues.

For example, you are defending genetic scans, but when you look out a thousand years, the timing becomes irrelevant. We begin to have to ask *very* basic questions that have never been asked on television, as far as I can see: What is it going to mean when we start getting interplay between artificial intelligence and implantation technology, and the ability to transform our genetics? Right now we may be dealing with practical, immediate things. But to come up with concrete issues and place them in the future and make them gripping so that we really get people thinking about the larger challenges of the future: I think that is the calling of a program like this, whatever the initial strategies are.

Palfreman: That makes me further think that one way to approach this might be to put it in classes, so there is a class of issues that arise from our present and immediate future. It is a way of not only dealing with the funding organization but of dealing with regular people. Most people aren't ready to jump straight to the long-term future; they need to be introduced. There are things that are in the short-term future; there are things that are medium-term future; and there are things that are very long-term future. You somehow have to legitimize the debate. People watching have to feel that this is a reasonable thing to do.

In the old days, human meant that you were part of the clan… Now we are making a planetary grouping…

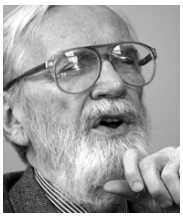
Andreadis: If you want to legitimize the debate and make it not the "same old, same old"—I do agree that the treatment is very good, but it is very conventional and it overlaps significantly with things I have seen—I think you might want to center it on the question we asked earlier: What has it meant, and what will it mean, to be human? If this is your overarching question, you can make your horizon as shallow or as deep as you like. You could start by saying: In the old days, *human* meant that you were part of the clan. Every Indian tribe on this continent, if you translated their name, it meant *the human beings*. They treated their captives like animals until they learned the language of the tribe. Now we are making a planetary grouping; being human now means something else.

Incidentally, being human is also a question of whether women will be treated as full humans. When I looked at this video, it said, "The Future of Humanity"; now, I saw men on that video. And looking around the table, I am the Queen Bee here. Count how many women are at the table. I am not telling you this to tell you that women are different; in fact, I think women are the same, and therefore should be treated the same.

But if you use the question of what it will mean to be human, you can open the debate into: Yes, genetic engineering, and germline alteration, uploading, downloading, speciation, hybrids between silicon and carbon.

My other suggestion, which might be a hook for people, is that you might want to put science fiction links in here. It doesn't have to be sophisticated science fiction, but this is something with which people resonate.

Gregory Stock: The mention of science fiction is important, because while you are trying to justify the science and make this solid, what the mass audience has seen is science fiction. I find that I am always saying things that I think are very aggressive scientifically, and people are saying, "Can't we already do that?" Images of the future are all over the place, and we have to tread that fine line between those two realms.



…we have for the first time in any species in history developed the capability to intervene and influence our own evolution. That should be the central theme.

Coates: I recommend that we deep-six the existing treatment. It is so seriously misshapen that we would be wasting the next day to try to improve it. Fundamentally, what it is, is a list of the last six months of discussions in *The New York Times* put into an interesting presentation format. It would be great for another purpose, but not this one. First, there is no mention of the year 3000. Second, there is no fundamental notion of human progress. Third, you have this absolutely stultifying, deadly kind of thing that television has fallen into: "on the one hand … on the other hand." Kass and Fukuyama are so ideologically hidebound that they are not worth two minutes to listen to. The objection should be summed up and dealt with in a very positive way. "On the one hand … on the other hand" is the kind of thing that is killing journalism. If you produced this the way it is, it would be utterly passé within five years of production. That is how fast things are going.

What is missing as central to this are themes, first, of progress. Second, that we have for the first time in any species in history developed the capability to intervene and influence our own evolution. That should be the central theme. We can do something absolutely unique in history: influence our own evolution and also the evolution of every other species with which we choose to intervene.

Furthermore, the values issue should have as its centerpiece that we know, from everything that occurred in the industrial era and even before, that new developments change social values, so we have to escape the trap of thinking of an enormously beautiful future in terms of "Presbyterian thought 1890." We have to look at the fact that the values will change along with the technology. That is an interesting assignment.

The third thing we need to do is get at the question, perhaps a sneak preview, of the year 3000. What are the most important, interesting, high-probability things one can say of 40 generations from now? I think the most interesting thing 40 generations from now is that we will begin to see variations among human populations that are the early antecedents of true evolutionary change. There is no evolutionary change in a mere 40 generations, but very interesting predecessor developments.

What I am seeing here, from the way you have laid this out, is that what you are proposing to do is ordinary, routine television production. It ain't gonna do the job. We have to look at humanity; we have to look at the year 3000; we have to be progress-oriented. We have to have the centerpiece of change around the ability to influence our own evolution. You can see that we can't improve what you have done; we have to scrap it and start over.

With all the talent in this room, I would like us to say: "By the year 2100, I see the following could occur … by the year 2600, I see the following could occur …" based on the good, solid things we see going on now and their reasonable extrapolations into the future. That would give you the bag of information, the bag of concepts that would allow you to redo this in an interesting way. Now, I have no idea how eager or enthusiastic the group might be about making those kinds of conjectures about the future, but that is the only way you are going to be able to present anything of interest apropos the Foundation's concern: Humanity 3000.

If you want to predict the future, you have to look at the past. It is a continuous process.

Jeffry Stock: Athena's statement was excellent, about going from a clan to a planet. That has genetic implications. And no one has addressed Walter's statement, which was that we are going into a genetic decline. If you want to predict the future, you have to look at the past. It is a continuous process.

The other point I want to make is that the idea that we can control our evolution and that we are unique as an organism in being able to do that is not correct. All organisms control their evolution.

Coates: That is a play on the word *control*.

Jeffry Stock: I think what you are really saying is that *you* could control our evolution if you had the ability to manipulate what all humans are doing and their mate selection and so on, but that is a hugely complicated issue. We are making assumptions about how special this time is. Of course, it is special now because we are here.

Andreadis: *We* are here.

Jeffry Stock: Yes. The best of times; the worst of times.

…there will be a society in which an increasingly advantaged, genetically advantaged, elite part of our society has increasing power over the rest of us…

Hughes: I want to second what Greg, Athena, and Joe have said. This treatment read to me very much like *20/20* ethics, as opposed to year 3000 ethics.

Talking about science fiction, one of the things this treatment has to address is the basis of people's anxieties and what I think lies behind Kass's and Fukuyama's anxieties about the future, and that is concern about power and diversity in the future. We have to touch on—I don't think we should spend a lot of time, but we have to touch on it—the history of eugenics, the association of the idea of the improvement of the human condition with authoritarianism, and the difference between having a vision of the future in which people have *self*-control (where parents have procreative liberty to make these kinds of decisions) and where we have a democratic society—and the potential threats that human enhancement and cyborgization and all these other technologies may pose to having that kind of society.

In other words, go back to Lee Silver's ideas that there will be a society in which an increasingly advantaged, genetically advantaged, elite part of our society has increasing power over the rest of us, in which certain parts of our society become so different that they no longer have any capacity for solidarity with the rest of us, and us with them, and therefore it leads to some kind of civil conflict. Those are the kinds of scenarios I think people are very concerned about and which we do legitimately have to address.

It leaves out the consideration that the paths we choose are ones we choose, not inevitably determined by the technological prowess we have.

Fowler: In the treatment of this projected film, it struck me that the operative word was *inevitable*. There is so much "gene-speak" in this treatment that it doesn't speak to the point that needs to be brought out in this film: the fact that there are ways in which we can choose to go. There is input from the citizens themselves as to what directions they want to take. When we get so much

of the sense of genetic essentialism and determinism and inevitability, that seems to override all of the examples that are in this film. It leaves out the consideration that the paths we choose are ones *we choose*, not inevitably determined by the technological prowess we have.

Palfreman: There is a tendency here, as we have already heard, to marginalize people; for example, the idea that Kass and Fukuyama are being silly. These are people who challenge essentialism. Is it the case that this group is really skewed one way rather than the other? Your point is that those other views have to be represented. How would they be represented?

What are the principles that are going to be operative over a long period of time?

Campbell: I think there is a question that comes before what we are going to foresee for the future. It is: What is the basis for our prediction or fore-viewing? There are a variety of bases. One is religion. People have speculated a thousand years into the future from religious teachings. That is one basis. Another basis (and I get the feeling that some people are exploring it here) is what we want to happen. Then again, most of the discussion so far has been predicting the future or assessing the future in terms of extrapolating from where we are now.

My feeling is that there is another way to go, and that is to look at principles. What are the principles that are going to be operative over a long period of time? Principles of chaos are one example: What will chaos theory tell us? What can thermodynamics tell us about progress? After all, thermodynamics is really the only progressive scientific theory. Above all is the theory of evolution: What has happened to humanity in the past has been evolution. What is *going* to happen to us will be evolution. We have this feeling that from now on our evolution is going to be quite different, as Jeff mentioned, but yet we have controlled our evolution in the past. All organisms control evolution; we are just at a different level of choosing our evolution. And I suspect that in the future we are going to have still more powerful levels. In every time you can say that it is unique, because if you have an exponential curve and you look at what is happening at any one point, it always seems as though *this* is the point of takeoff.

One way to organize a television program would be to examine the various ways to infer what is going to be in the future. A religious view and a humanistic view and an evolutionary view lead to very different expectations.

…there are always going to be new and totally unforeseen events that can radically change the way we see the world.

Zimmerman: I would like to follow up on some of John Campbell's remarks. First, I think he is quite correct to note that the way this has been outlined for this meeting is an extrapolation based on what we are dealing with in the present and what we know in the present. There is one point that we have to be always cognizant of, and that is that there are always going to be new and totally unforeseen events that can radically change the way we see the world. These events certainly include advancements in science. We have a long way to go even in theoretical physics, let alone biology. And we have so many lessons from the past that we can look at to sober us up. Those should erase the smugness that "we are almost there," that we essentially know everything except for mopping up a few details.

Put yourself in the mind of somebody in 1800, prior to James Clerk Maxwell's elucidation of electromagnetic propagation. The concept of communication across the oceans would have been unimaginable, as well as the idea that we could have flight. This is 200 years, not a very long time. Even going back 100 years, there are many things we take for granted today that were not even dreamed of back then.

A more recent and very cogent example occurred when I was on the faculty at Johns Hopkins, where two of my colleagues, Dan Nathans and Ham Smith, were doing the very pioneering work that has enabled genetic engineering to take place. Ham Smith was trying to figure out why certain bacteria can resist bacteriophage, by so-called restriction-modification, which led to the elucidation of restriction enzymes, which in turn enabled gene-splicing. It did not occur to them, by their own admission, even in the early 1970s, that this would revolutionize the whole field of genetics and allow interspecies gene-splicing. They saw it as a research tool; it was very interesting; it elucidated the natural phenomena that interested them at the time.

Accordingly, we really must be prepared for the unexpected, or we are just going to look silly. And if you look at a lot of the futures scenarios of the past, how successful have people been in extrapolating? You can extrapolate from what we know, but you can't extrapolate from what we don't know.

Coates: What are the implications for the video of what you said?

Zimmerman: The implications for the video are that we have to recognize the existence of uncertainty at all times. Maybe Athena's suggestion that looking at science fiction might even give us more guides to what we might expect, rather than sticking purely to the facts, deserves serious consideration.

Palfreman: That might give us a license to do it. What we are looking for is a literary device that will enable us to do something.

…we are trying to say what the sphere of possibilities is for where these technologies might take us…

Gregory Stock: An issue has come up related to whether we are controlling our evolutionary future or not. Just because the tools that are at our disposal let us strongly impact it in a shorter amount of time, and just because there are colorful things going on today, does not mean that we control the future in the sense that we can plan it out in some way. The chaotic emergence of whatever the human future is, is something that we can make projections about. We can extrapolate existing technologies and suggest where they may take us. We may not be right, of course, and we probably won't be right, but nonetheless it will be powerful as a stimulant for thinking about the future.

I don't think we are really trying to be right; we are trying to say what the sphere of possibilities is for where these technologies might take us, given our best understanding of what we know about technology, about biology, about evolution. I think that is very important.

…once evolution has chosen something, it will go to the logical end of that fork, but each time it chooses a fork, that fork is not preordained.

Andreadis: On the question of uniqueness, evolution can be both inevitable and unique, because each moment a decision is made, that decision is somewhat at random, and it is influenced by chaos theory in that it is sensitive to the starting conditions. If the asteroid had not fallen on the Yucatan Peninsula, the dinosaurs would not have become extinct, and the mammals would not have developed to be the dominant species. We would probably have intelligent sauroids ruling the Earth. So, there is innate inevitability in that once evolution has chosen something, it will go to the logical end of that fork, but each time it chooses a fork, that fork is not preordained.

So, on the question of evolution and controlling it or not controlling it, we can do something with it, but in fact it will go on without us, just as the universe has and will go on without us, regardless of what we do.

Gregory Stock: Let me make a comment about Francis Fukuyama and Leon Kass, because I have debated both of them a number of times. Kass was asked the question: "Are we going to do these sorts of things?" He said, "Yes, we are going to do it. It is obvious that we are going to do it. But that doesn't mean that we have to *want* to do it. We will try to delay it." So, they too see the ways that these technologies are shaping us. We need to evaluate the power of this type of control to decide whether the debate going on today will be significant in any way in shaping the distant human future.

…it is obvious that we will transcend organic matter as the basis for intelligence.

Hughes: When we talk about chaos theory and the ability to predict the future, I am leery of Joe's suggestion that we try to say what is going to happen in 2500; what is going to happen in 2600. I am much more of the school (perhaps minority school) of futurists who would argue for the concept of the Singularity: that there is an unknowable boundary beyond 50 or 100

years from now, at which the confluence of these technologies will make the future of the human race so unpredictable and so strange that it is pointless for us to talk about it.

That said, I think there are nonetheless some strange tractors out there beyond that chaotic point that we can still talk about: things such as the fact that humanity will expand beyond this solar system and that we will probably be well on the way to colonizing other stars by the year 3000—whatever our descendants are, whatever form they take. For me, it is obvious that we will transcend organic matter as the basis for intelligence. Whatever the descendants of the human race will be, there are so many advantages to not being organic that we won't be organic anymore.

We need to think about it in that way: There is no point in sitting down and saying: "This is going to happen in 2500." We need to actually introduce in this treatment the idea of the Singularity since Kurzweil and many others are beginning to make that a popular concept.

How do we get this debate to be about more than just people like ourselves…

Palfreman: I can see that all that is fascinating. How does a theologian participate in this debate? How do we get this debate to be about more than just people like ourselves, thinking about the cool things that could happen in the future?

Andreadis: You could take two extreme stands. One is that the theologians have their own channels that are fully dedicated to them. And they do not invite scientists, that I know of, to debate them.

Palfreman: We want to invite them.

Andreadis: So, you must decide if you do want to invite them for your format. That is up to you. The other point is that we have been invited here to discuss this as concretely as possible to help you with this particular program. It is true that all futurists are really "presentists." We speak of what we know. And if you look at predictions, they are 50–50; they are about as good as hitting dartboards. So, we can either play it safe or we can dare to be silly—or to be seen as silly by our descendants. I think it is all right. The question of the inevitable will pop up.

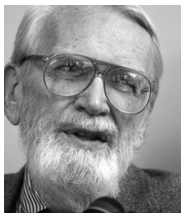
One thing about the treatment I wanted to mention is that when I read through it, my sense was that it was joyless. You mentioned Sagan's *Cosmos*, which was a groundbreaking series. It is dated by now, but it was a big deal when it happened, and it was wildly popular. The reason, of course, was that the guy had stars in his eyes. As he was talking about it, it was exciting; it was wonderful; it was lovely. Yes, you have the darker undertones, but it is exciting; it is wonderful … and people will adopt it because it gets threaded into the fabric of their everyday lives, like *in vitro* fertilization—right? It is not just the rich who nowadays have *in vitro* fertilization. Regular people say: "I want a child. I can get a child by *in vitro* fertilization and I am going to have it done."

There was a sense in here—there always is in these programs—of hubris: "We are transgressing; a thunderbolt will come from the firmament and burn us." This is very much the dualist Christian thing: the good; the bad … we; the other. We have to be a little pagan here and be pluralistic about it: be optimistic and pragmatic at the same time: "Yes, it will happen. It may happen in a good way; it will happen in both good and bad ways, but it is going to happen. *How* is it going to happen? And why is it exciting?"

Palfreman: The issue you have to bear in mind is the audience, and your audience is overwhelmingly nonpagan in this country. We can ignore this for the purposes of the discussion, but if we are serious about a television series, I don't think that will fly. So, I would like us to think about how to include some of those views, rather than just marginalizing them.

Religion and culture are certainly central to what happens genetically to humans in the future.

Jeffry Stock: In terms of the fundamentals of genetics, religion has a heck of a lot to say. Religions have traditionally played an important role in the determination of mate selection. That is a fundamental issue if you are going to address the issue of where human genetics is going: How are we going to select mates? On what basis are we going to do it? That is what religion is all about; that is what culture is all about. Culture is going to determine where we are going. Religion and culture are certainly central to what happens genetically to humans in the future.



…any attempt to introduce science fiction into this will convert the whole thing into trash.

Coates: Two points. One on science fiction: I think any attempt to introduce science fiction into this will convert the whole thing into trash. There is a fundamental principle in logic of formal systems that if you introduce a counterfactual, anything else is possible. I would just abjure any consideration of science fiction, as the program becomes then just another *Star Trek* with no limitation to what you would be able to introduce and say.

On the more important question of control, somehow it is difficult for people to see *control* meaning anything other than some top-down fascist telling you what to do. I don't see that model at all. If you look at genetics today, it is primarily directed at correcting diseases and disorders. The next emerging stage is going to be improvement. For example, we know a very specific case: When low-cost human-growth hormone became available, parents of children who in their early years had been forecast very reliably to be a boy maturing to five feet tall; a girl to four feet eight inches, those parents knew that their children's lives would be better if they were three, four, or five inches taller as adults. And those parents were ready to have their children injected with human-growth hormone. Now, that is a fundamental feature of our society: We want to enhance the ability of our children to get on in the world. This is a clue to what will be applied to genetics when we complement the corrective element with an improvement element.

Then the third stage, which is much further along but comes technically out of the emerging ability to correct and improve, will automatically lead to the capability to enhance. The capability to enhance people, to give them characteristics beyond what would, for them, otherwise be normal, is an inevitable part of the unfolding capabilities from genetics. So, the three stages are disease-correction, improvement, and enhancement.

Now, how is this going to come about? How do you keep the fascistic leader from getting on with this? Well, in my discussions with Leon Kass, he has two characteristics that cripple his negativism: First, he sees this coming top-down; he sees somebody in charge, forcing this on society. I am going to deal with that question. The second thing is he sees humanity as something that is fixed, and he wants to save it and preserve it. I see humanity as something fluid and changing. As our values change, the nature of humanity will change.

Coming back to the question of the top-down, in our American society, nothing is going to be introduced genetically from the top down. It will always be the patient's choice; it will always be the victim's choice; it will always be the enhanced person's choice. And things will go wrong. As things go wrong, we will learn: Don't do this; don't do that. We will learn five, seven, ten, 12, 25 years later that something went wrong that we had not anticipated, but in a democratic society, the social feedback mechanisms are what neutralize this sense of the fascistic control. I am thinking of control in a democratic society through the normal operations of: "Do what you want within certain restrictions, and then we will all see what happens, and then we will take the corrective measures."

…the real question for the future of genetics has to hinge around this question of human enhancement.

I am not particularly concerned about the disease-correction and the improvement. I am talking about what is really going to shape the next 40 generations: the enhancement question. And that has to be the interesting focus for the future. I am sure we could get some reasonable agreement that of the 300 most important diseases and disorders, we are going to have them genetically under some kind of control within the next 50, 60, 70 years. They are going to cease to be problems—maybe not for everybody simultaneously. But the real question for the future of genetics has to hinge around this question of human enhancement.

Walter Kistler: I think that is a very good point.

Campbell: We can't approach the long-term future in a linear-causal fashion. We can't use linear thinking, because the factors that are going to be most causally important in shaping the future are ones that have not developed yet. The mechanisms that are around today are irrelevant. For example, a fair amount of what Mr. Coates discussed, of whether a tyrant will run things a thousand years from now or whether decisions will be made from the bottom up from a moralistic point of view. But our current morals have nothing to do with the morality of a thousand years from now. We get trapped if we think that we should explore how the near term *should* eventuate so that the long term will be the way we want it. It is like the kid who says, "I am glad I don't like spinach or I would eat that awful stuff!"

Jhirad: I would like to comment in support of what Jon Palfreman wrote. I am a screenwriter for television and have done a lot of television shows, mostly for PBS. Television is a different medium than a book. It involves storytelling, and that is why I think science fiction is something important to possibly bring in. It involves possibly a journey. There are a variety of ways of telling this. I just want to remind all of us that this is a storytelling medium. Second, there have to be emotions involved. If you can't *feel* this story, it's not true. That is what is different about a movie: There has to be emotion involved. It was pointed out earlier that there is a degree to which we are not entirely sure what will happen. That creates a certain amount of suspense that will be necessary to drive you through this story. There has to be dramatic tension in this.

One of the persons I had thought of was Maurice Wilkins, who has been through two of the great scientific achievements of the 20th century: One of them was the development of nuclear weapons, and the second one was in DNA. He won the Nobel Prize, with Watson and Crick, for this work. He has become very worried recently, seeing what is happening with the efforts to control human evolution. You can have different journeyers, different people who may be taking a journey. There are various ways to tell the story, but I just wanted to yank things back to thinking about this as a storytelling medium.

Velamoor: This might be a good point to go around the table to see if we can get our arms around what has been said so far. Dr. Anderson, would you like to start?

…what we are now in the process of doing is trying to develop in utero gene therapy for humans.

Anderson: What I observe is that people are grappling with the implications of what I spend my time trying to do. We developed the genetic engineering for humans and what we are now in the process of doing is trying to develop *in utero* gene therapy for humans. We have pretty good control of getting genes; what we now have to do is learn how to control those genes. I have just leased a building about the size of this one specifically for developing the next generation of proteomic work to be able to isolate the proteins that control the stem cells. This is all being done with Craig Venter. What I spend my time doing is trying to develop the technology, and what is fascinating is listening to everybody talk about the implications of that technology.

My thoughts about it were wrapped up in large part in the film *Gattaca*, for which I was a scientific consultant and which basically presents what I fear. I am certainly a believer in science fiction, because science fiction is a way of telling a story that is interesting. People found *Gattaca* interesting. I must have talked to a thousand different audiences about the implications of where we are going. *Gattaca* reached a thousand times more, in a thousand times more interesting way, than any of my lectures, so I would strongly support having an interesting story. If you are talking about what is going to happen a thousand years from now, by definition it is science fiction. I don't see how you can get away from it.

Coates: How would you deal with a proposal that we will talk about teleportation of people in the year 3000? Or we will talk about wormholes in the year 3000? Where is the constraint?

Anderson: How many people read Jonathan Glover's book, *What Sort of People Should There Be?* [in paperback, Viking Penguin, 1984]. That was superb and it looked at several things—one is genetic engineering—and he wrote at the very beginning: "We're not going to worry about whether it is possible or how it is done or the moral implications, but just: What is it going to mean to society?" Another is a transparent mind. If I know exactly what you are thinking right now and you know exactly what I am thinking, how is that going to change our society? Teleporting was a third one. So, it *can* be done. It was done by a scholar from Oxford. It was done very well.

Coates: I am not saying it can't be done or you can't write about it and make it interesting. I am saying: What does that do to the intellectual integrity of attempting to deal with humanity in the year 3000? You abandon all intellectual integrity when you introduce the impossible, because the viewer can then no longer sort out the impossible from the plausible.

Anderson: Well, regarding teleporting I agree; that's *Star Trek*.

Coates: How do you draw the boundary?

Anderson: That is why you have people like me here, because that is what I do. I have a joint appointment at CalTech in applied physics and in the Department of Pediatrics at the University of Southern California. I'm not going to talk very much here, but if someone pro-

poses teleporting, then I will speak up, because that is *not* going to be possible in one thousand years.

Hughes: But enhancement …

Anderson: But enhancement absolutely can be done and, of course, I am on record as being very concerned about how we go into it. Is there going to be enhancement? Of course there is going to be enhancement. It is *how* we go into it that is my concern.

Velamoor: I would like to get back to the treatment and, with all the discussion so far, see if we can get our arms around what we are suggesting at this point. Could each of you take a minute and say, "Here are two things that have been said."

…all of this is projected science, and we can be very realistic about making reasonable projections about the science without going into fantasyland.

Gregory Stock: There are a couple of key points that have come up again and again. One is the idea of focusing on the longer-term implications and trying to develop mechanisms for grappling with them. That is the most interesting thing we can do, and if we do not do it, then even if we have a television show, it won't be very interesting.

Another question is the extent to which the shape of that future is buffered from many of the kinds of arguments that are going on today about, for instance, whether we should allow human cloning—decisions about these early stages of the technology. Regarding the comment French made—"Of course we are going to have enhancement, but how we are going to go into it concerns me"—it seems that we would do a great service if we could identify those things about which even Leon Kass and Francis Fukuyama would say, "Of course we are going to do that in some form."

The third thing is science fiction. I think that all of this is projected science, and we can be very realistic about making reasonable projections about the science without going into fantasyland. But we still are dealing with projections.

Coates: If you have the censor to do that, you are better than 999 out of a thousand.

Gregory Stock: We have the people in this room easily to do that. I deal with projecting into the future, and we don't talk about teleportation or things of that sort.

Coates: But the point is that if there is to be intellectual integrity, you have to have a rule, a concept, by which you draw the line, because your sense of what is acceptable might be quite different from mine or from French's or from Fowler's. The question is the intellectual integrity of this program. The Foundation is here in business for a thousand years. Is it going to be laughed at in the year 2200?

Velamoor: I think that is what Greg is saying—that as long as it is rooted in the solidity of what *is* possible.

…you might as well say that there is nothing we can do without either compromising the rigor or appearing silly. In fact, both things will happen…

Andreadis: You can argue about semantics if you like, or you can argue that you are more rigorous than X. In the end, it has to be a narrative; it has to be a story—a journey, if you wish. We don't necessarily know the landing place, but we can give alternatives for what the landing spots will be. It has to be a story because of the medium and because of what we are thinking about it.

Secondly, we should not take ourselves too seriously. That is a problem with talking heads in television. You know that even if you are intellectually rigorous … if you look at how intellectually rigorous some Victorian statements were, they were as intellectually rigorous as they could be; they still sound silly or wrong. So, we have to do it to the best of our ability at this point, with the leavening of understanding that all of these things will change—the facts, the values, the humans who look at this a thousand years from now won't be like us. This is what we can do; otherwise, you might as well say that there is nothing we can do without either compromising the rigor or appearing silly. In fact, both things will happen, but we still have to do them.

Campbell: One way around this "being silly" would be not to have *one* scenario, but to contrast the scenarios that come from different points of view: a humanistic point of view, a scientific point of view, and maybe even a science fiction point of view. I think you could have some exciting journeys by presenting the various ways people are trying to look at what the future is going to be like. You could be quite upbeat and you can preserve scientific integrity because some of these visions avowedly are not scientific visions.

Hughes: Personally, I think we should stay away from religious scenarios. I would hate to see an inclusion of a discussion about whether Jesus is coming back or not. Let's assume that is going to happen in the millennia after. But I do think that science fiction can be used as a touch point, and I think it is absolutely essential because science fiction has shaped so much of our thought about this already: *Brave New World* comes up in every discussion you have with the public about this, as do *Gattaca*, *Frankenstein*, etc.

It would also provide an opportunity for creating some of these narratives. You could say: Here are some of the futures that have been thought about: H. G. Wells's *The Time Machine*—a radical separation between the *have*s and *have-not*s where there is exploitation between them. You could use those to crystallize people's understanding of the kinds of issues that are at stake and the kinds of futures that are at stake. In terms of the possibility of robotic intelligence becoming hostile to humanity, *Terminator* is one of the classic images of that. I don't think we should be talking about: "Is *Terminator* going to happen?" versus "Is *The Time Machine* going to happen?" But we can use them as touch points for the options that are at stake.

Andreadis: I would be wary of making artificial divisions out of seeing the future religiously or scientifically or humanistically. I am a scientist, but I consider myself a humanist as well. There is this business of Snow's *Two Cultures* and never the twain shall meet, but in fact, in the end this has to be an integrated vision, because we are talking to humanity. As for religion, the Asian religions see this very differently from the way we do. They see cycles and so forth. So, which religion are you going to present without taking over the whole program—in which case your focus has irretrievably shifted.

Although you don't want to do "on one hand … on the other hand," you may want to express a plurality of viewpoints, not just one. You don't want to polarize them either, because you want an integrated vision in the end.

Palfreman: The way this discussion is going is not particularly helpful to us. People have talked about form; they have talked about science fiction; the discussion has become very vague and terribly general. It is just not very helpful. We have to bring it back to the sense that this is not like *Cosmos*, and we are not looking at the history of science that has already been written.

There is a big issue here about science fiction versus what Joe Coates has said: that somehow this is not just science fiction. There is still the question of what we are going to talk *about*, what gives us legitimacy to talk about these things. There is a device question. Maybe, as Athena says, we should go back in time, look at the past singularity, and say, "That was unpredictable; look what it changed. We are going to look at a future singularity." That might give us a way to get into it. But I am with Joe: There has to be something that constrains or grounds what we do, to help us be specific.

The last thing I want to comment on is the way we have excluded all the people who are religious. I think that reflects this gathering; it is just not very broadly based. I still would like to push for that.

This film has to be developed, initially, to lay out a platform for discussion, for dialogue, about where we want to go as a society…

Fowler: I agree that there has to be a practical aspect, a relevant aspect to this treatment as a film. French mentioned *Gattaca*; I really don't know anyone in the bioethics community who doesn't use it in one way or another, especially in what we call "the Studebaker scene": producing the child in the natural way and then going to the technological side of the issue. That is a real grabber, but that is about the only part of *Gattaca* that really resonates with audiences. I meet thousands of high school students a year to engage the issues of where we are going and what it means to be human—questions that are so well established and laid out in that film. But it is always surprising to me in the audiences I meet—both in the communities and in the classrooms—how few people have seen the film. In other words, it may have some resonance, but it doesn't take them very far down the road.

What I have heard so far in the discussion is that we probably want to lay this out in parts, beginning with the road we are on, and if we continue on that road, this is where we will go; then establishing something in the future that is a new road. We need to bring people into that discussion. This film has to be developed, initially, to lay out a platform for discussion, for dialogue, about where we want to go as a society: Which roads will we choose to go down, and how do we get involved in that process? Simply having a menu of what we are able to do and where that might take us isn't going to be relevant, isn't going to impact people the way they live their lives today. I don't see the film that has been laid out here as

being substantially different from all the ones that have already been produced, but bringing in different aspects of the disciplines to weigh in on this is important.

I was recently at a debate—that's what it turned out to be—with theologians on stem cell research. I was interested to see how little possibility there is, at least for those represented on the panel, for any kind of dialogue. They simply appealed to their religious doctrines to say, "That is easy for me to answer, because this is what our religious doctrines tell us." And that was the end of the discussion. It wasn't: "Where do we share commonalities between our religions?" That wasn't discussed and didn't seem to be on the table at all. To me, this kind of film must take us into the realm of discussion. At the end of it, it lives way beyond us; it lives beyond what we are able to do today with the technologies, but lives into the future of humans.

There is a way of getting to people, but you can't do it by talking heads …It has to be where it hits, and that is your child, people you love…

Anderson: When you are dealing with people who have a set agenda, the way I deal with people like that is to realize that when they come to me because they have a child with a genetic disease, they are different people. Even Jeremy Rifkin, who is actually a good friend of mine, although according to the press we are bitter enemies—Jeremy said to me (and I think he said it publicly) that if he had a child with ADA deficiency, he would come and get it treated by gene therapy. There is a way of getting to people, but you can't do it by talking heads in discussions around tables. It has to be where it hits, and that is *your* child, people you love, people you have an emotional attachment to, and in some way be able to reach into that.

Coates: I think we are unconsciously underestimating Jon [Palfreman] and Barbara [Moran]'s competence at creative filmmaking. We got caught up in "it must be story … it must be this … it must be that." We are hearing a lot that says it has to be like every other television program we have seen. I don't believe that is so. If we can give Jon and Barbara the set of conclusions we come to about the following millennium, let's let them play out their creative imagination on how to do that. I don't know whether children should be there, whether babies should be there, whether Hindus and Buddhists should be there; I don't know whether it should be a story in the traditional sense, but perhaps Jon can create an entirely new concept of what a story is. I think that we shouldn't tread on Jon's property. His intellectual property is being creative. Why don't we give him the content that he should be playing with in that creativity?

My second point is that J. Hughes made a point that was in the nature of a self-report but he generalized it: "I can't look out 100 years … I can't look out 200 years … I can't look out 300 years." I can't contradict a self-report at all, but to generalize that to "it cannot be *done* that we look out 100, 200, 300 years" is a gross exaggeration from a self-report. I would suggest that this evening you read the last enclosure in your binder. It is a paper of mine that looks out 600 years and draws a thousand-year conclusion, and talks about specific things in each of those 600 years. Now, you can tromp on it, denounce it, say it is foolish and stupid, but at least somebody—me—made the try to do what J. said cannot be done.

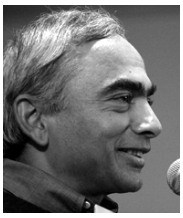
Velamoor: In a sense we have come one full circle: basically saying leave the production of what one sees to Jon and Barbara and Anna, but work on giving them the background and the materials that they can use to mold it any way they see fit, which is what we have laid out for the rest of the workshop.

Kirk Citron: I want to go back to Sesh's three questions. I think they would be very useful to spend time trying to answer.

Velamoor: Essentially they boil down—strictly in the technical realm—to correction, improvement, and enhancement. Greg pointed out that clearly there are enough brains in this room to be able to get our arms around what those three concepts mean over the long term. The second part has to do with the question: What are the complexities that arise insofar as the fixing of things or the improvement or enhancement in a genetic sense? And how will we go forward? If we go forward, what are the constraints? Does it include religion? Does it include other constraints that societies may impose on themselves? Is it top-down or bottom-up? That is the second area. I know it is linear, but even so, the production of the television series would have to look at it in some form. At least it gives substance to the three components that become the basis for whatever you do with it. The third area is enhancement.

What I would like the group to do next is consider: Are those three adequate or should there be a better description or a change to the three issues that have been laid out for the workshop?

Palfreman: State the three issues again.



…if correction, improvement, and enhancement were to go forward, what are the factors that will impinge on the debate concerning implementation?

Velamoor: There are three suggested issues. One: Conversations to examine scientific and technological breakthroughs for the future human. Discuss form; function; type; capacity; physical, mental, and emotional characteristics. Conclude with a consensus. That is strictly staying with the technological bounds, but divisions have been offered that make it even more helpful and those are correction, improvement, and enhancement. That is Issue No. 1. Let's stay out of the simultaneous inputs as to what religion means to this, or whether it is top-down or bottom-up. I think that coloration can be added to it. That could be the second issue that is discussed.

The second issue that I had suggested is: Conversations on legal, moral, ethical, religious, psychological, and philosophical issues arising out of the implementation of scientific and technological breakthroughs. In other words, if correction, improvement, and enhancement were to go forward, what are the factors that will impinge on the debate concerning implementation?

The third issue I suggested is our discussion on whether it is top-down. Some countries might try it top-down; some countries might ban it altogether. On the other hand, as I understand things to have happened in the past, these things will happen anyway. Will it follow some evolutionary process of trial and error, reactive adjustments, corrections, and then trying something else? I cannot see that there will be any universality or complete agreement on an approach to any of this, whether it is on a national basis or a religious basis. The pagan religions, which Athena referred to, probably would have no conflicts with any of this. So, it is a matter of increasing the complexity of how we deal with it in steps.

Those are the three issues I proposed. The purpose still is to give Jon the background and content.

Palfreman: I will make a counter suggestion for you to think about. Why don't we just take those three things Joe gave us—correction, improvement, enhancement—and make them the basis of the three discussions? I think we would get much more specific information that way. Then you could bring in the other material. In correction, for example, French would be able to give us lots of information.

Gregory Stock: The idea of correction being a significant influence on the shape of the human future seems to me rather unlikely. This is just improvements in medicine, and it seems to me rather uninteresting. The focus on issues of enhancement and change, and the intersection between technology and biology—that is the one that we really need to get into.

Velamoor: We have to go in steps, and then blend it. Let's take the three issues—correction, improvement, and enhancement—as influenced over the next thousand years by politics, religions, morals, ethical issues, and the other complexities. Overall, how will this interaction unfold? Let's see if those three are adequate or if we need to fine-tune and sharpen them, or go to something entirely different. I would like to identify the three main background issues that would help Jon in going forward.

Palfreman: We have to pin this group down. Either we take the short term, the medium term, and the long term—that is, do it temporally—or we take the issues of correction, improvement, and enhancement. I would like to pin everybody down to talking about something specific, then bring in whatever other material.

Gregory Stock: What is the difference you see between improvement and enhancement?

Palfreman: The first group might talk about correction over the short term. The reason it is important to talk about correction is that any general viewer watching this discussion would find it intriguing, but eccentric. They would be alienated by this discussion, because it assumes that everybody is on board. Your audience has to engage, and the way they will engage is with the present existence of these issues and technologies. The same is true of the funding agencies. So, whatever form this program has, it must have that.

We can take corrections; we can take improvements; and we can take enhancements. And we can talk more about enhancements than the other two, but we have to confine ourselves to the subject for the time period we are discussing it. Otherwise, people can end up being very general.

I would also like to keep us thinking about other views, simply because your audience out there is involved with them. What often works is getting a view from a surprising quarter; for example, a religious view that is actually in favor of germline engineering. That can get people's interest because it is surprising and it opens their minds to consider these things. If they hear everything from technocrats and futurists, and they don't want to hear it, they will turn their brains off. If

the message is something people don't want to hear, you have to use different kinds of messengers. It may not be Leon Kass, but it has to be represented in some way that actually resonates with people; otherwise, they will simply switch off this discussion.

The third thing is that even though science fiction would be an interesting form, I don't want to keep going back to that until we have engaged with this content as much as possible.

What are the ends we can safely assume will continue for human beings that will lead us to want to use these technologies to change human nature?

Hughes: In addressing this continuum of issues from correction to enhancement, for me there is no ethical difference that is interesting between these. The real question is: What are the ends we can safely assume will continue for human beings that will lead us to want to use these technologies to change human nature? The ends, for any foreseeable future, will be that people will want to live longer; they will want to have more abilities; they will want to have less disease and more able bodies; they will want to be happier; and they will want to be smarter. If you just assume that all of those are intrinsic goals of human life, all the technologies will, both for corrective purposes and for enhancement purposes, serve those ends to the extent that we allow people to use them.

Anderson: I disagree that there is no ethical difference between correction and enhancement. I think one can draw a very precise line. It is a precise line in a very gray area, but what correction is, is taking an individual who is below normal—whatever *normal* is defined as, because of illness, injury, or whatever—and bringing him up into whatever the norm of society at that particular time is. Enhancement is taking a normal person and raising him above.

Hughes: But that is a definitional difference, not an ethical difference.

Anderson: No, there is an ethical difference based on justice as to whether you take a person who is below what the norm of his society is and bring him up into that norm, or you take a person who is at the norm of society and put him above the norm.

I do wonder, with Greg, what the difference is between improvement and enhancement. That seems to me to be two different words for the same thing.

Velamoor: I think that separation was introduced by Joe.

Coates: Yes. Let me explain what I meant. On the tentative distinction between improvement and enhancement, take the case of the children who are going to be five feet tall—perfectly normal, healthy children. Their parents want to in some way improve their life chances, so they want them to be four or five inches taller. Even if it worked, the children would be bigger, but nothing else would be changed in terms of what the goal was there. So, I would see that as improvement.

Enhancement may include not just traditional categories above the average. Look at this case: We now know the gene that causes some insects to see in the ultraviolet. Wouldn't it be interesting if some of us could see in the ultraviolet? It might not be profitable and it could even be destructive, but this would be an enhancement in which you go beyond the normal range of expectations or of possibilities for most people. Some of it might be exogenous to our species. Some of it might be endogenous to our species.

Suppose, for example, that you are a world-class violinist and you have a strong desire that your children should be world-class like yourself. The very fact that you are world-class means that you are probably one in 100,000 or one in 200,000. That is more than mere improvement if you could find the genes that would allow you to give that gift to your children. That is the distinction I was making, and obviously with those kinds of distinctions, there is always a fuzzy edge.

…what we might look at as true enhancement would be…using synthetic genes, genes that are really not within the human repertoire…

Zimmerman: Just to expand a bit, maybe one way to look at this is that there is a class of modifications, which a lot of us have been thinking of as enhancement, which would utilize the available human gene pool and the alleles that lie within that, maybe optimized in a single individual. That could certainly include world-class musicianship, high intelligence, a super immune system, etc. However, what we might look at as true enhancement would be, as you suggested, adding new

or non-human traits such as allowing us to see in the UV, probably by using synthetic genes, genes that are really not within the human repertoire, and that is where we are headed if we are talking about forced evolution of the human species into something that isn't human, *á la* Greg's book [*Redesigning Humans*], for example.

Andreadis: Going back to having someone—for example, a religious person—telling you that he *is* in favor, Leon Kass is one of us; he is a technocrat. If you want to do that, invite a rabbi; invite a *bona fide* representative. Many Orthodox Jews will tell you there is no ethical problem in Judaism, if you want to take nonpagans. So, if you want to do that, do not take surrogates. Kass is not a religious man or a representative of a religion. He is representative of ethicism, which is a different story.

The other thing is: I agree with the distinction between improvement and enhancement. I would consider enhancement as something that is outside the human repertoire. For example, if you want to go to Mars, you might want to be able to photosynthesize yourself, rather than being dependent on plants. That is a very extreme example. So, there is a difference between the two: Improvement is within the possible, and enhancement would be beyond the repertoire of human.

Gregory Stock: In trying to think of what the important issues are for us to cover, one of them is the notion of therapy, enhancement, extension, or however you want to frame that progression. Another is the issue of biology and nonbiology, and what the interplay between them is going to be. The underlying technology is very important to us. When you talk about biology, people ask, "What about artificial intelligence and the transcendence of humans?" That is another possible topic that I think is very important and might deserve consideration separate from the issue of functionality.

The third is the issue of the individual and society—how this will occur. Will there be small groups? We talk about it as though it is an individual thing, but what about the choices? This is a journey and it is not an individual journey, because this knowledge is collective and is then being applied to individuals.

A final issue that came to mind was that the specific topics we might talk about within enhancement are very important within themselves: for example, changes in human reproduction, changes in the way we handle our emotional states, longevity.

Zimmerman: Trying to look at this as an exciting television series, I think there is one caveat that we have to heed: We must not limit ourselves to looking at everything from the point of view of the elitist Western US society. We have to take into account that we are on a planet with a lot of people, and most of them don't live in the United States or Western Europe. Most will not have available the technologies as they are developed.

Dealing with the technology is one part, going up through enhancement, but then we are faced with what already has been observed in contemporary society: that in the Indian castes where you have isolated intermarriage or breeding you can already identify caste by certain genetic markers. This exists. I think it was Murray and Jensen in *The Bell Curve* who proposed the very controversial statement that there was already a genetic underclass because the wealthy and highly educated tend to intermarry within their own group, and the poorer—and perhaps innately disadvantaged—people do not intermingle with them. Over many generations the result was a big difference in abilities, with fuzzy boundaries, of course, between a privileged *intelligentsia* and ordinary people. This is, of course, a very controversial concept and not accepted by many people.

As we get into enhancement therapies and the application thereof, first of all, it is going to be available to a very small number of people, whether done by parental autonomy or by some other mechanism. This will guarantee the social dichotomy postulated by Murray and Jensen. How do we then deal with the social bifurcation that will occur? Are we going to start developing an elite superclass that is possibly in conflict with the bulk of the rest of the population? Is this something that is going to be confined to the West at first? These are all questions I think a television series has to look at very seriously.

Gregory Stock: How does that reflect on the topic areas?

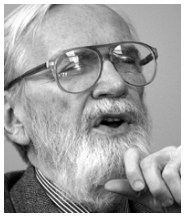
…this series may not ignore the global and political and social contexts…

Zimmerman: I just don't think you can talk about evolution of the human species, or the extension of the human species into something possibly different, without taking into account the context in which all of this is occurring. Technology is one thing. I think we all agree that, yes, we are going to have enhancement, and it is going to be technically feasible. But this series may not ignore the global and political and social contexts in which this operates.

Andreadis: The existence of elites is not a Western phenomenon; it is actually global. Every human group has managed to define and establish an elite. The definitions vary, but they are there. As far as access to technology goes, I think people will get access to technology that takes care of what they want. For example, people in northern India and China have managed to get access to ultrasound and to stop having daughters. These are people who are illiterate, but they know about this and they use the technology because they want sons. Although it is important to add this and to show how culture influences the use of technology—these are very specific examples. *De facto*, this technology is not something that is constrained to the Westerners.

I wonder how much of our social interactions are determined by our genetics.

Jeffry Stock: So much of what we are involves social interactions. I wonder how much of our social interactions are determined by our genetics. I have been thinking about this for a long time. This is a largely homogeneous group in terms of genetic background, with one woman. Women have certain interactions and men have certain interactions. Are there differences and how important is that? If you define an elite as a group of people who have a similar genetic background and communicate with each other better, that doesn't mean that they are superior people. How much does that play out? That seems to me to be extremely important in how our genetic future is going to play out.



…a modest amount of coercion must accompany these kinds of changes.

Coates: I want to suggest three things for the agenda. Two years ago I spoke to the National Science Board, which is the group that governs the National Science Foundation. I gave them a general briefing on the future and began to talk about genetics. I was trying to make a point to them about the future developments of genetics. Probably the entry-level IQ for the board is 145 IQ; it's a bright crowd. I said, "Wouldn't it be a very interesting world in which you were average, instead of in the top one or two percent?" What was interesting was the nonresponse. They were dumbfounded by that possibility. They just sat there looking at me, as if to say: "Well, what's coming next!" Even for the people who might benefit or enjoy or find value in a change, the idea can come to them as fresh and shocking—and, in this case, paralyzing. They just refused to address my question: "Wouldn't the world be better off if you were average?" I explained, of course, that I did not mean dropping them down, but raising everybody else up.

That carries me to the point that the brain has to be an important part of this program. Whatever number you prefer today—60 percent, 80 percent—that determines the size of the vessel, and the rest is the environment: Those kinds of changes are probably going to be far more controversial than those that are merely physical or visible. That has to come into our discussion in some way.

The second point that has to come in is the issue: How will genetics, as we move from correction to improvement to enhancement, lead to new special-interest groups? Will the beneficiaries come together in a way that will have its own significance? My own view is: Yes, in the 40 generations between now and the year 3000, we will begin to see variations of people. But what will happen in the mid-range? Will the people who have benefited come together as advocates? Will they come together as a special-interest group? Will they come together because they have a unique magnetism for each other?

Well, what kind of nonsense is that? Let me illustrate. One of the great benefits of the internet today is that if you have a bizarre, offbeat, or minor interest, instead of boring to death the people you encounter daily, you can get on the internet. Let's say that I am interested in 1890 Czech stamps. There are five of us in America; 35 of us in the world. I don't have to bore you over lunch; I don't have to bore you on Monday morning. I can get together with the other 34 and we can have the time of our lives.

Now, what happens when we alter people's capabilities? Will they form these kinds of *ad hoc* affinity groups, and what will be the consequence of that?

The third point I want to make—it is surprising; we have touched it tangentially, but not directly—is the question of governance over this emerging capability. I think that a modest amount of coercion *must* accompany these kinds of changes. Now, what *modest* is—how much and so forth, that's the interesting point. Let's take a particular case. At some point it will be necessary,

desirable, and maybe even required by law that pregnant women have a genetic test at, let's say, two months or three months—something early in the term—to determine if there is something wrong with the fetus.

Now, what happens when you determine (let's not even specify the disorder) that the fetus is going to be severely handicapped, and we know, from all the accumulated information, that when that child is born and grows up, it is going to be about a $1.3 million deficit to society, but the child has a correctable condition? You see the dilemma. The child has a correctable condition; we know the terrible cost to society, aside from that of the parents, of allowing the child to come to full term. We could intervene. This is the point at which I see a form of benign, low-level coercion.

Now, how could you coerce that person into taking advantage of gene therapy? What I would do is deprive them, if they choose not to do that, of any future governmental support in terms of any health care. Make it clear; make it unequivocal; make it stick. Now the would-be parents have a new choice to make.

How does governance come in? What might be subsumed under this concept of mild coercion?

Palfreman: We are opening up ideas again, massively. Can I make another plea that we do something like: Take one generation into the future, ten generations into the future, 40 generations into the future—and constrain to say that *all* we are going to talk about is one of those at a time?

Coates: Why not just 40 generations?

Palfreman: Because we can't bring people straight to 40. We can't do that.

Velamoor: The reason we are going around the table is to talk about whether the three issues outlined in the book are the three issues we want to focus on in the sessions coming up—or should they be changed?

Campbell: I support very strongly Jon's approach because the problem with looking at what is going to happen in 40 generations gets tangled up with what is happening in one generation. You look at 40 generations in a very different way. One generation involves linear thinking; for 40 generations, it doesn't matter where we are now or what our current attitudes are to various possibilities. Forty generations requires a different sort of analysis. It would be very interesting to get that point across. I think it will really help to separate these three periods of time.

Velamoor: Assuming we do that, then are we saying that for each time period, we take all three issues and consider them?

In 40 generations, gene correction is not going to be important. It may be very important for the first generation.

Campbell: Well, some of those issues are not going to be important for some time frames. In 40 generations, gene correction is not going to be important. It may be very important for the first generation.

Velamoor: So, what do you want to change here? These are three issues that have been outlined: correction, improvement, and enhancement in terms of the technological possibilities without muddying the waters as far as the influences that are going to impinge on it.

Palfreman: I want to tie it down more. I want to say: one generation, ten generations, 40 generations. Within each of those temporal constraints, you can talk about what you like. I think we will get something useful if we do that.

Anderson: I can take a crack at one generation—just the technical aspects—and then other people can take it from there.

Velamoor: Good. We will get to the meat of the issues in the three discussions following.

Gregory Stock: There are three pathways for organizing this. One is to do so temporally and exert very little organization on the content itself. The real problem is in keeping it focused.

The second way is by subject matter, and I had proposed that there are further divisions of subject matter, like the balance between the nonbiology (machines) and biology.

We need to make a decision about which of those is to occur and perhaps we need to do some suborganizing. If we are going to organize temporally, then it will be important to put in the subject categories as divisions within those rings and then closely moderate so that we have discussions on point rather than ranging around.

Velamoor: If we stick to the temporal without these divisions, we will be jumping back and forth between three and it will be impossible to distinguish.

Gregory Stock: So, I would like to suggest that we actually make temporal divisions because there are very different processes that come to bear in looking different distances ahead, and that within the temporal frameworks we divide by subject matter. That subject matter will probably change somewhat as we change our temporal divisions.

Jeffry Stock: Technically, if we are talking about genetics, I can think of three areas: breeding, genome engineering, and gene therapy. Is that what we are focusing on?

Velamoor: I don't think the technique matters so much as what the outcomes will be.

Jeffry Stock: But gene therapy is fundamentally different, because it is another kind of intervention.

Andreadis: It strikes me that the temporal division and the three subject divisions are the same: The first generation is correction; the ten generations division is improvement; and the 40 generations, enhancement. So, we don't have to argue about temporal versus this division, because that is the way it is going to be.

Fowler: That occurred to me as well. I think that would be a good way to break this down, but I don't hear much about the ethical or social issues. Are we going to integrate that into each of these areas?

Velamoor: Yes. Each period will take each one separately.

Coates: Could I make the suggestion that we not treat the issues as controversies, but treat the issues as solvable problems? The trouble with dealing with the issues at each point is that you end up with "on the one hand … on the other hand," which is as dull as dishwater. Why don't we take the issues and show how they have been resolved, and not even discuss the pros and cons, but show how they have been resolved so they become part of a positive story, whatever the issue may be. For example, if we have an issue about stem cell research, "there was a controversy about this; here is the status of stem cell research today." Or, the question of decaying values in humanity, you show positively how that was dealt with rather than the "either/or" stuff.

Palfreman: It might be "if/then" content: If this happens in ten generations, then ….

Coates: I would like you to be more positive: It *happens* in ten generations.

Palfreman: I am happy if we just stick with the temporal divisions, because I think we will get somewhere.

…we will have challenges to our understanding of the self and the continuity of the self and the boundaries of the self…

Hughes: Jon, your draft is pretty good on the one generation. It covers a lot of the territory that needs to be covered.

Joe, to reflect on something you said earlier about the need for potential state policies to encourage parents to use enhancements that would benefit their children—which I do think is a policy issue we are going to face, probably in this century—one of the issues we have to grapple with here is extrauterine gestation. It goes back to *Brave New World*; it goes back to Haldane. In this last century, we went from zero percent hospital births to almost 100 percent hospital births. In the next century, we are probably going to have extrauterine gestation, artificial wombs, and those will obviate a lot of the maternal autonomy issues and also make the issue of fetal rights much more pertinent.

For me, the really challenging issues—and they are probably ten-generation issues—concern the decomposition of the self. It gets back to what Joe said about the brain. As we have control over memory, as we have control over aspects of personal identity, as we have cybernetic implants and backups of our brain and we are able to share in high-bandwidth ways our thoughts and feelings with other human beings, we will have challenges to our understanding of the self and the continuity of the self and the boundaries of the self that will be much more difficult for us to communicate. Talking about the fact that people might have blue skin is one thing; talking about the fact that people might not think of themselves as separate individuals anymore is another.

About the schema of correction-improvement-enhancement, I think that within ten—or maybe just two—generations, we are going to have genetic aesthetic issues that will not be just correction, improvement, or enhancement. We will have issues of people wanting to use genetics to explore animal/human boundaries, adding various kinds of animal attributes, for instance, UV sight perception, gills, or whatever. Right now there is a philosopher who has split his tongue and added bumps to his head and tattooed gills onto himself, because he wants to explore being a reptile. Those kinds of people will exist as well in the future.

Velamoor: Somebody said we needed science fiction; we could just introduce him into the show. Are we satisfied with this schema, correction-improvement-enhancement? There were a lot of subsets mentioned, but I think the technologies, whatever they are, can be subsumed in those three categories, whether it is therapy or engineering or biological or augmentation or carbon or noncarbon. I think we are where we need to be to go forward.

Coates: One comment to Jon: Violating my own suggestion, I want to play in Jon's sand pile for a minute. As we look at the kind of material that is already in Jon's outline, it would represent the current situation. I would like to see that handled in an entirely different way from having Mary Jane on display and Mary Jane's condition and Mary Jane saying, "how happy I am." I would like to take about 25 conditions and have them go from an image of the crippled, impaired, limited child—click-click-click—to the perfect child. I would like you to avoid going through the story of Mary Jane and her family and how she recovered, and just treat the genetic possibilities, the practicalities, and show visually the result.

For one, we see the spina bifida victim getting out of the chair and walking around, after you have just shown that same child unable to move, unable to have locomotion. I want to get power into this without tedium. I want to get power into this so that you can time-delay and place interesting intellectual material, so I am suggesting that one way to do this would be through a series of photographic snapshots.

Velamoor: I'm glad you said that you wanted to play in his sand pile before you said that. Anybody here, if you have suggestions for playing in Jon's sand pile, let's keep that offline at this point. Be perfectly free to communicate with Jon subsequent to the workshop those kinds of inputs on how to go forward.

It is the conceit of reason to believe that you can decide in advance what is "best."

Campbell: You cannot worry just about content. To be meaningful you must also explicate the premises for looking ahead ten generations. Now what about 40 generations? It is a supposition that we formulate a long-term policy that will lead to a preconceived outcome. However, Hayak pointed out that it is impossible to foresee the eventualities from the social program. It is the conceit of reason to believe that you can decide in advance what is "best."

I submit that the only way to make statements about humanity 40 generations from now is from evolutionary principles. I don't think that is necessarily the case for ten generations.

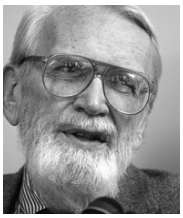
Velamoor: It may turn out that as we see it unfold, it may follow some kind of a survival-of-the-fittest process.

Campbell: In one generation, it is hard to see how you would have survival of the fittest.

Velamoor: I am saying that Leon Kass is saying what he wants to say; Francis Fukuyama is saying what he wants to say; Greg goes about debating them saying what he wants to say. The ultimate outcome is not a victory for any one of them exclusively; it is some intermediate compromise. Isn't that how it unfolds? There is constantly a reaction to whatever is being proposed; it is some inherent moderation that is taking place.

Gregory Stock: I think what John is saying is that if you are looking 40 generations ahead, you have to look at the evolutionary principles of how generational successions are taking place, what kinds of competitive advantages are arising reproductively in terms of the embracing of the various technologies. In one generation, you have a political process. There is still a lot of competition involved, but the same sorts of evolutionary succession or generational succession are not involved. For each time frame, we have to think about what assumptions we are making about what are the primary influencers of the outcomes in that realm.

Campbell: Yes, and especially about whether causality is linear or whether it is dominated by feedback from changes that have not yet happened. It is hard to predict the changes from causes that have not yet come into being.



There are three principles that guide my futures work…One is that you can see the future to an extent that is useful.

Coates: As a futurist, I want to defend my futurist turf. When somebody says you can't do what I earn my living doing, it raises a grave concern. There are three princi-

ples that guide my futures work, and that of other futurists. One is that you *can* see the future to an extent that is useful. You don't have to have perfect clarity; it doesn't have to cover everything; it only has to be useful.

Second, we have the capability to intervene to make the undesirable less likely and the desirable more likely. Those are a very modest pair of assumptions about dealing with the future. I don't see how anyone can object to that. We can see to the point of the useful, and we can act to the point that makes some things more and other things less likely.

Then the third principle is that we have a moral obligation to use those two capabilities to anticipate and to influence.

Campbell: Take the case of welfare: Should we have still more welfare or less? You may say that we should have more welfare so we have a more lenient society. It may turn out in the long run that it was better to have it the other way so that people are weaned from this trap. I don't think you can predict in advance which is going to give the best outcome.

Velamoor: And I don't think you need to. There will be proponents of more and there will be proponents of less, and whoever wins, wins.

Campbell: What I am saying is that you can extrapolate outcomes for short periods of time but not for longer periods of time.

Coates: What is your limit of where you can't do it? Five years? Ten Years?

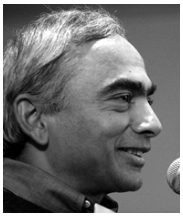
Campbell: That is an important question. The physicists talk about relaxation times: You energize a system or put it into a non-equilibrium state and see how long before it decays back or loses memory of that perturbation.

Velamoor: We will break for lunch. When we come back, we will take up our three discussion segments.

Discussion of Major Issues

Guidelines

The crux of the workshop was a series of three major discussions addressing the content of "The Future Human" program. Here, the possible approaches to the task are summarized with guidelines for the approach selected.



…the best way to get our arms around the material is to focus one at a time on three separate time periods…one generation…ten generations…40 generations.

Velamoor: We spent the last hour defining and refining what our discussions should be as we proceed into the heart of the workshop. One possibility was to go with the three issues originally planned, which would place the first emphasis on what the actual scientific and technological advances are that create possibilities for biological transformation; the second part of the discussion would focus on how those technological possibilities converge with the complexities that will arise (the legal, moral, ethical, psychological, and philosophical issues); and the third part would deal with implementation: top-down, bottom-up, etc.

A differing approach suggested in this morning's conversations was to focus on the three areas of correction, improvement, and enhancement. In other words, some of the scientific and technological advances offer correction for existing conditions such as diseases and disorders; some would mean improvements to humankind as we know it today; and some would go further and enhance or change human capabilities to something that would presently be beyond the normal human realm.

The third approach suggested this morning was that we break the discussions into three parts by looking at the material temporally, with the three segments being one generation, ten generations, and 40 generations. With this approach the only constraint would be temporal; that is, we would confine our comments to only what would be possible in the given time frame. Some advances that would be very important in one time period would not be important in another.

Our conclusion was that the best way to get our arms around the material is to focus one at a time on three separate time periods. The first is the next 25 years or one generation; the second is the next 250 years or ten generations; and finally the third is the next thousand years or 40 generations. Within each discussion segment, you may talk about whatever you think fits that time period: scientific and technological advancements, social or political or ethical questions related to those advancements, implementation, ramifications, correction, improvement, or enhancement.

The three discussions will be led by scholars here at the table: I have asked French Anderson to lead the session on the one-generation time frame; the second, on ten generations, will be led by Gregory Stock; and the third, thinking about the thousand-year, 40-generation future, will be led by Joe Coates.

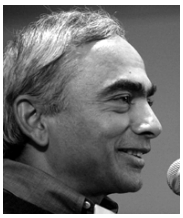
Please remember that our goal is to provide the best content input possible to our producers who are going to be revising the treatment for the program based on what they hear from you.

Major Issues Session I

One Generation (25 Years)

This session focused on scientific and technological advances affecting humanity that may reasonably be anticipated to occur in one generation's time (the next 25 years).

Discussion Leader: W. French Anderson, M.D.



Please confine your thinking…to what is scientifically likely to occur in the next 25 years that will bear significantly on the future of humankind.

Velamoor: We have nominated three scholars to lead the three separate sessions. The first one will be led by French Anderson. Please confine your thinking in the first session to what is scientifically likely to occur in the next 25 years that will bear significantly on the future of humankind. Dr. Anderson, you have the floor. To the extent possible, let's stay within our format.

Anderson: I need a little better framework of exactly what you want this to cover. Is this to be the framework of what we anticipate the future human will be one generation from now?

Velamoor: Yes. The first session will probably emphasize corrections, leading into improvements. The second one will focus on improvements, leading into enhancement. The third one will focus on enhancements. You can also get into the influences that are likely to impinge on these possibilities as they occur. Start with the technological possibilities and then add in the complexities and how the dilemmas will get resolved.

Anderson: Okay. I can start with an overview of where we will probably be in one generation, and then throw that open to let people agree or disagree. Then we can move into influences. Are we calling one generation 25 years?

Velamoor: Yes. That is the standard.

…by 25 years from now, gene therapy, gene-based medicine, genetic medicine will probably be a treatment/cure for most major diseases.

Anderson: In terms of the genetic/medical field, by 25 years from now, gene therapy, gene-based medicine, genetic medicine will probably be a treatment/cure for most major diseases. That means that if humans don't die of cancer, heart disease, etc., the average age of the population will expand to where there will be just two things that people die from. One is simply wearing out. That depends on one's total genetic framework, but most people start running downhill by the age of 80. Without diseases—arthritis and so on—having a major impact, the chances are that the majority of people will live to 100 or over, except from trauma. We are still going to have car crashes; we are still going to have planes crash and volcanoes erupt and earthquakes and so on.

Gregory Stock: Will you clarify: You are suggesting that by the year 2025 the majority of people will live to be 100?

Anderson: The potential is for people to live to be 100. They won't be 100 yet.

Gregory Stock: But that will be the life expectancy of people born in 2025?

Anderson: Yes.

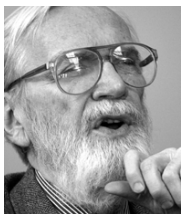
Gregory Stock: And are you imagining this to be because of interventions that are somatic?

…the majority of people will live over 100 years.

Anderson: Yes. Somatic interventions. And where my numbers come from is about ten years ago I worked with the Department of Commerce, which actually has a group of far-thinking people—in fact, some that

would be very comfortable around this table—thinking about the future implications on American society in the realization of what gene therapy could do. They were looking at what would happen in the United States, from an economic standpoint, from the Department of Commerce's point of view, if over the next 20 to 25 years, this were the case. The actuarial numbers I am talking about were defined by their statisticians. You get rid of the major diseases; you take the known actuarial increase in age; and the number you come up with is that the majority of people will live over 100 years.

Hughes: That is probably not a universally accepted number in the field of longevity, because people like Jay Olshansky [*The Quest for Immortality: Science at the Frontiers of Aging*, 2001] have looked at this as well: What would happen if we could get rid of cancer, stroke, and heart disease as the principal causes of mortality? Even if we could then go on and get rid of the degree to which dementia increases mortality, what is the natural life span? Most of them are relatively conservative about maybe getting up towards 100, but certainly not past 100 years. But I am glad to hear your optimism.



The notion of life expectancy going to 100 without a genetic intervention to move the set point seems to me at least controversial and highly questionable.

Coates: Leonard Hayflick [*How and Why We Age*, 1994] was at a meeting of the American Association of the Advancement of Science two years ago and he made two points: Life expectancy and longevity are different, and he took longevity to be the latest that any member of a species has lived. For human longevity that is 122. Life expectancy is, of course, the forecast of survival patterns of a population. But this hinges around the concept of the set point: that every species has a set point. The way I read the literature, the human set point is somewhere between 85 and 90. Secondly, if you wiped out these three big killers *and* everything else, if you wiped out all causes of death, you would add only about five years to life expectancy because of the set point.

The notion of life expectancy going to 100 without a genetic intervention to move the set point seems to me at least controversial and highly questionable. I am just raising the point with you: Do we need to go quite that far?

Anderson: You just righted yourself with the last couple of sentences, because what Hayflick is known for, of course, is the Hayflick Phenomenon, and that is how long a cultured cell line, which isn't quite the same as a species, survives. It is certainly true that we do have a point where the repair of our cells is overcome by the total amount of degradation, so we just slowly go down. That set point *can* be changed; it has been changed in Drosophila (in fruit flies); it has been changed in other species; and it can be changed in our species. When you finished, you said, "unless you genetically change the set point," and you are absolutely right.

Coates: That is big time for the next generation.

Anderson: It won't happen in the next generation—that is true—but simply based on the actuarial (and you are correct that "life expectancy" is the appropriate term, not "longevity"), life expectancy will continue to increase and the estimates that were done ten years ago predicted over 100. It might very well be that it will be less than 100, but I don't think anybody disagrees that it is going up. That is going to have a major impact.

Hughes: What about chemical mimics of catalytic restriction, which is something that is coming out in the next couple of years?

Artificial hearts, artificial livers, artificial pancreas, artificial you-name-it, except for brain…

Anderson: There is a whole range of things, and I was going to mention a few in categories: There is the genetic category, as Joe mentioned; the biological/medicine category, which includes a lot of things such as artificial blood, artificial calories, and so on. That will have an impact. Another major impact will come from the fact that we will have nanotechnology sensors. That is one of the things I work on at Caltech. Artificial retinas are not that good yet, but are certainly coming along. Work is being done at Caltech on artificial cochlea for hearing, but I can't talk about it because it is still in the early stages. Artificial noses and artificial tongues are being developed. Will they be ready in one generation so that people actually have artificial noses? The chips will be there; the chips are almost there now to be able to duplicate what the human nervous system does in terms of olfactory sense, but how to connect

that chip to the appropriate nerves in the nervous system is what the big issue will be. That probably will not be in one generation.

Other things in terms of correction: certainly artificial joints, artificial almost-any-single-thing except for brain. Artificial hearts, artificial livers, artificial pancreas, artificial you-name-it, except for brain; that is going to take the ten-generation time frame.

In one generation we can have correction of many mental problems, but we are certainly not going to improve there except in the sense with drugs. J. Hughes and I were arguing earlier whether by 40 generations we could change the reptilian base of our brains. I am talking about the actual hardwiring, and I don't think that will happen for a thousand generations. Maybe it will. But being able to alter the effect by drugs or by software changes, yes, I think that will be possible.

Zimmerman: In this study of actuarial data, you said the mean life expectancy would be over 100. What was the standard deviation? Was that included?

Anderson: At this stage, I don't remember. The Department of Commerce was primarily concerned with the implications for society: What do we have to take into account for our administration? It was a Republican administration, so it must have been early [George H. W.] Bush administration—thinking that if their administration was still in power after 20 years, what do we have to worry about?

Gregory Stock: In talking about what is possible within the next generation, you talk about gene-based therapeutics. I assume you mean somatic gene therapy of some sort.

Anderson: Yes. And nanotechnology, MEMS [MicroElectroMechanicalSystems] technology.

Gregory Stock: Yes. But still, if you are going to go in and do genetic interventions, it seems to me that somatic therapy is probably the hardest problem that you could possibly have: to get in and target correctly and move in significant chunks of DNA that are properly regulated. It seems to me extraordinarily optimistic that we will be able to do that broadly. To have those sorts of impacts, we would have to be able to not only retard the progression of a variety of age-related diseases, but also reverse them in some sense, which is very challenging. You obviously think that is possible. Could you talk a little more about those technical challenges?

…we will be able to put in several genes, regulate them properly, and reverse conditions in the next ten years, certainly in the next 25.

Anderson: Yes. The technical challenges of using genetic engineering have to do with being able to develop gene-regulation, which is the normal human physiology. What we have done up to this point is to use viral control regions, regulatory regions, because they are the easiest to do. The human body can sense a viral regulatory region in a similar way that it recognizes viral proteins, and basically shuts them down. What is now just beginning is to start using human regulatory sequences to run human genes, and getting rid of all the viral sequences. At least in animals, this looks like it might get us over the enormous hurdle where one simply can't get enough delivery, enough gene product in the right place at the right time.

One looks at progress and predicting, and you are predicting that if the curve is going up, it will keep going up. Based on what we know as of now, in terms of gene regulation, yes, we will be able to put in several genes, regulate them properly, and reverse conditions in the next ten years, certainly in the next 25.

Gregory Stock: Technically, how do you get those into a particular tissue—target it at a particular place in a chromosome?

Anderson: The first targeted vector we have developed—we now have approval from the FDA to go into a clinical trial—is to engineer the envelope of the viral vector, put into it a recognition domain that recognizes a specific receptor, and now that vector can be injected into the vein and it goes to that receptor. That is where it attaches. It has taken a fair amount of engineering to learn how to do that, but that is now possible to do.

Andreadis: I actually use a lot of this technology. The bottom line is that although we know the genome, we actually do not know the regulatory sequences of most of these things.

Anderson: Absolutely, that is the problem.

Andreadis: Oddly enough, germline intervention is technically the simplest and easiest.

Anderson: I agree.

This business of "the selfish gene" is a very good sound bite, but it is quite incorrect. In fact, genes do not act in isolation.

Andreadis: Somatic, which is the least controversial ethically and otherwise, is in fact the most complicated. The other thing that we have to remember is that genes do interact. Dosage is important. That is where you get things like Down Syndrome—that is a dosage problem, where you have a little too much or a little too little of something. This is not a system where each gene acts in isolation. This business of "the selfish gene" is a very good sound bite, but it is quite incorrect. In fact, genes do not act in isolation. They are part of this large feedback loop. If you want to put something in and have it react exactly the way it should, you basically have to reconstruct the whole context.

…gene therapy, where we correct a specific defect, is ethical…and should be done, but enhancement or improvement is dangerous to do at this point in time…

Anderson: You are absolutely correct, and that is the reason I have argued now for about 35 years that gene therapy, where we correct a specific defect, is ethical, appropriate, moral, and should be done, but enhancement or improvement is dangerous to do at this point in time—for precisely the reason you just said. We are not dealing with simple little systems where A goes to B goes to C goes to D, and if there is a problem with B, you can just put in a new B and everything works fine. The analogy I use is this: If you are watching television and you are not a television engineer; the television stops working; you take off the back and you see a broken wire. It is not unexpected that if you replace the wire, your set will work all right. But if you go over to your neighbor's and his set has a clearer picture than yours, so while they are off in the kitchen, you take off the back and you see a box there that your set doesn't have, so you unscrew it and run with it over to your house and screw it into your set—what is going to happen? You are going to blow your set, because you don't understand what the television engineering is and so you can't just make changes. If there is a broken wire, you can correct it, but you can't improve it unless you understand the engineering.

We don't understand the human body. We don't understand human cells. We don't understand the human mind—that is why it is dangerous to try to go with improvements. Even though technically we could do some of the things now—like transgenic humans; we could make a transgenic human right now—but for scientific, ethical, and moral reasons, we should not do it.

Velamoor: I read a line in one of your papers describing the complexity: A gene affects all characters, and a character is affected by all genes.

Campbell: Ernst Mayr said that—as "an admitted exaggeration."

Andreadis: The other thing, of course—and actually one of the things that make me often not watch this type of program; it also makes this business of control become important—is the "all-defining" gene. Not only do genes not act in isolation, but they define less than people think. That is why the question of introducing the brain/mind is important, because in fact your brain is defined by your genes only at very specific key moments—switches—while you are made. For example, you will become mentally retarded if A-B-C during your genesis, but once you are there, and you are normally formed and you are normally wired, then your wiring depends on so many other variables that it is almost useless to discuss things like "the genes for intelligence," because these are susceptibility, or preference, or possibles—without becoming a humanist, mind you.

Anderson: You can correct, but you cannot enhance.

Andreadis: Right.

I would agree that these things will be corrected, but I don't think it is going to be through gene therapy…

Jeffry Stock: I understood that you said that we are going to be able to use gene therapy in the next 25 years to correct illnesses like cancer, diabetes, and so on. Now that is really like an enhancement, because there will be incredible issues of long-term effects. It is a very difficult way to go.

I would agree that these things will be corrected, but I don't think it is going to be through gene therapy; I

think it is going to be through other mechanisms. I don't see the evidence that gene therapy is going to correct cancer or diabetes—I mean Type II diabetes—and some of these other problems.

Hughes: I want to go back to an earlier comment. I don't think there is a serious ethical difference between enhancement and correction. The question for the safety and efficacy of these procedures, which I do think have to be politically regulated and guaranteed, is predictability and the balance of cost and benefits. For a kid who is going to die at age five of a terrible disease, then whatever unforeseen consequences there might be to a genetic intervention, we are willing to take that risk, whereas we are not as willing to take that risk if it means an increase of 20 IQ points over 120, or something like that.

However, the issue is still the same: Can we guarantee that the balance of risks and benefits, and predictability of the effect are worthwhile? Within one generation, don't you think that the computerization of modeling of proteomic effects and degeneration of the body, and our animal models, will allow us to have some guarantees, some confidence, that some of these interventions will be worthwhile? Perhaps it may take a generation—I'll grant you that—to reach this level of certainty, but within one generation, we will say: "You know, this one gene effect here is so pervasive in reducing aging-related diseases, this is something we should consider doing."

Anderson: Once again, your last sentence makes me agree with you. Up until your last sentence, I disagreed with you. I think what Lee Hood is doing in systems biology is absolutely critical for the future, as well as what a number of people are doing, and computer modeling is something I spend a lot of time doing, as well as animal models. But I think that even in one generation, we are not going to get that far.

But your last sentence said: Won't there be situations in which you see that a single gene has such a dominant effect? And in that you are absolutely right. But we are not going to understand a cell in one generation, because it is just too complex.

Coates: Will you tell us your feeling about the legal relaxation on the germline interventions? That would seem to be extremely important. Second, at a more technical level, suppose I am a black couple and we have sickle cell. Obviously it is a dominant and it would be very nice to eliminate it. It would be tremendously costly in human stress to wait until you have a fetus, run the tests, and then go through doing something.

Andreadis: It is actually a recessive, not a dominant.

Coates: But my point would apply to something that is dominant. I am thinking of a single gene. Wouldn't it be far more effective, less stressful, and a far lower cost to make that analysis at the ovum and sperm level, and make your intervention there?

I will argue vehemently yes for germline or no for germline; you just have to tell me the time frame I am talking about.

Anderson: In terms of your second question, the logic, the rational thinking absolutely goes along, but what it doesn't take into account—as everyone here knows—is human emotion, human feelings, human spiritual thoughts, human religion convictions, and so on. There are a lot of things that make a lot of sense, and that is one of them, but that is not going to happen for a while.

That gets to your first question: the legal implications of germline. I laid out about 15 years ago what I thought was the strategy needed for germline gene therapy. Every time the press asks for my position on germline gene therapy, my answer is, "Yes and no. If you are talking about now, the answer is *no*. If you are talking about the future, the answer is *yes*." I will argue vehemently *yes* for germline or *no* for germline; you just have to tell me the time frame I am talking about. What I think will happen is: As we understand somatic cell gene therapy and as it becomes more and more successful, and as we understand the true risk, as in the French youngster who got leukemia, germline gene therapy will be inevitable, and it will be inevitable for one reason, and that is human nature. What parent is going to willingly—I am not talking about hearing, but about a disease that causes suffering and death of their child—pass that defective gene if there is a simple, safe, effective, efficient technique for preventing it? So, germline gene therapy *will* happen; we just can't do it now.

Coates: What about in your time frame, though? You are talking 25 years, and we have to give Jon some guidance.

Anderson: I think that we *will* know in the next generation what somatic cell gene therapy will do. Let's expand that to gene-based medicine, because it is not going to be just gene therapy. It is going to be interacting genes with small molecules, etc. So, gene-based medicine, on the somatic level: We *will* understand it well enough that by one generation from now, I think the legal and societal acceptance of germline gene therapy will take place.

Coates: Will it be better, cheaper, socially more desirable to do this at the sperm/ovum level?

Anderson: Yes.

Coates: So, that may eliminate the otherwise somatic intervention.

Anderson: Correct.

…germline interventions will not make sense in the immediate future, simply because there is a much easier way of doing it…

Gregory Stock: I think that germline interventions will not make sense in the immediate future, simply because there is a much easier way of doing it, which is preimplantation genetic diagnosis—embryo screening.

Anderson: That's if you can afford it. There aren't many IVF clinics in Africa.

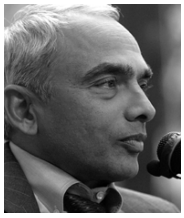
Gregory Stock: If you can afford germline, you can definitely afford genetic diagnosis. I cannot see any situations where germline is preferable to genetic diagnosis, except for a few odd situations and significant enhancement procedures, which are likely to be more complicated, more difficult, and therefore more distant. That's one point in the debate about germline.

The second is that I think it is unlikely that somatic engineering and the improvement of somatic therapies will be the key steps to germline therapy. I believe that somatic therapy is a far more challenging problem, because of your having to target genetic material. If somatic therapy works as well as you are hoping, then germline will be very quick, because it is so much easier. Somatic therapy might fail and have all sorts of problems—indeed, I imagine there *will* be some problems associated with it—and germline still might become desirable, the technology emerging from animal experiments, preimplantation genetic diagnosis, and the knowledge we are getting about our genetics.

Anderson: Greg, you might very well be right. I have to admit that I am biased because I have been the person who has been facing all of these issues with the regulatory committees. Everything I think about is biased on what I have to say to a regulatory committee. That is my own existence.

Yes, you might be right: It might happen, if somatic cell gene therapy ends up failing, that germline might be acceptable, but within our culture—you can answer this, because you are on the other side of the table sometimes—if somatic cell doesn't prove that it is efficacious and safe, I don't think our society (within our framework of one generation) is going to allow germline.

Gregory Stock: I am not saying that somatic will be a total failure, but that somatic will have a limited sphere of application with a number of diseases. Germline is a whole different set of complications.



What about somatic cell therapy for behavior and intelligence?

Velamoor: We have talked so far only about the health aspects. What about somatic cell therapy for behavior and intelligence?

Anderson: There can certainly be, and will certainly be, treatment of many behavioral problems and mental diseases because of a known defect in dopamine or a known defect in something else, but I don't think we know enough about the brain/mind to do any engineering, any enhancement, any improvement. You can do it with Prozac and other drugs, but to do it with genes, I think it isn't going to happen in one generation. Now, 40 generations—yes; maybe even ten generations; but one generation—no.

Where do you see artificial chromosomes?

Fowler: Where do you see artificial chromosomes? It seems to me that in terms of the efficacy of getting genes into cells and having them reproduce faithfully and using drugs to regulate their activity, artificial chromosomes might be useful. Where do you see that in this projection?

Anderson: I was a consultant to the first company trying to do artificial chromosomes, and I finally resigned from it several years ago because it is hard enough trying to figure out how to get a single gene in and regu-

lated correctly. An artificial chromosome is great in theory—John, I remember you at the UCLA Symposium pushing this. When we are talking about ten generations, that probably *is* the future, but my framework is one generation, and in one generation I don't think we are going to know enough for artificial chromosomes to have a significant impact in medicine or medical biology.

Campbell: You're thinking somatically, not germline.

Anderson: That is true. Now, in terms of transgenic animals and being able to do it—sure. But I am talking about in human beings and what the culture will allow people like me to do.

…you have to be able to modify precisely the genome the way you want without doing anything unexpected. We are quite a ways from that now.

Zimmerman: I would like to make a follow-up comment on germline intervention, especially vis-à-vis what Greg said. First of all, there is a small subclass of genetic defects for which preimplantation screening doesn't work, and for those only germline intervention would be a solution.

I agree with French that certainly the acceptability of the use of germline techniques has to depend on two things: First, you have to be able to modify precisely the genome the way you want without doing anything unexpected. We are quite a ways from that now. I had proposed a method that was a thought experiment about 12 years ago. Now most of the elements of the proposed method have been demonstrated, except for one critical one, which is the ability to plate and select embryonic stem cells cloned in the same way we do bacteria. There is a group at UCSF working on this now. The difficulty is that you can't get a clone from a single stem cell, even if you try it on a sheet of irradiated stem cells. They haven't figured out how to do that yet.

An alternative might be going the artificial chromosome route, and for reasons already discussed, it will be quite some time before we will be able to make one that is a precise analogue of a natural one. So, the reliability of the technique is the first point. The other point—we might be there in a generation—is to have enough characterization of the human genome and the effects of all the 0.1 percent that determine the ways in which we differ to be able to know exactly what we are doing if we do put in a precise genetic insert.

So: first, the reliability of the methodology has to be almost foolproof for it to be useful in humans, and second, we need much more knowledge of gene interactions. I suspect that within 25 years we will have most of that.

Anderson: That leads us into the second circle: There is now a clear place where the governance, the politics, the ethics, the legal side affect the technology, because if you can make a transgenic cow, you can make a transgenic human. We don't do it because of the second ring.

Coates: Let's make a simple assumption that within this time period, connected with all births and all prenatals, or both, there will be 175 disorders tested for routinely, and it will cost two, three, five, ten bucks—something acceptable.

Anderson: In one generation?

Coates: Yes.

Anderson: It will be much more than that. It will be several thousands.

Coates: I am trying to be conservative. What will happen to that couple who learn that they are carrying one of these extremely serious conditions? What actions will they take? My assumption is that they absolutely will take action, except for a tiny percentage who will remain paralyzed. The most important action they can take is abortion. The second one, of course, is the somatic therapy. But suppose the somatic therapy does fail and we have a further push on abortion. What is going to be the effect of, let's say, one in 20 conceptions ending with an induced abortion? That is going to have the effect of creating a tremendous pressure on the research community to find an alternative to that high level of abortion. What I see is that no matter what happens, there is going to be a search for alternatives to abortion, whether that is going to be germline intervention, prefertilization, or an improvement in the somatic interventions.

But we have to look at the side effect here. The side effect is going to be very hard to swallow from a public policy and a general public attitude standpoint, so I see that the rise in action associated with new knowledge is unstoppable. One of those actions is very questionable from the general perspective of the society. I think we need to play with that.

Anderson: I agree.

In terms of the implications, it seems to me that genetic profiling is going to be much more profound than somatic therapy.

Jeffry Stock: In terms of the implications, it seems to me that genetic profiling is going to be much more profound than somatic therapy. One in 20 pregnancies ending in abortion isn't really that high. I imagine that it is higher than that anyway today, and I think it is about one in ten that end in miscarriage, which is often a genetic problem. So, selection and genetic profiling—and then the marriage of genetic profiling with pharmaceutical and nutritional treatment—seem to me as having a huge effect in the next generation.

Anderson: I agree with all of this. We are pushing genetic engineering because of the long-term implications. I taught a session in an ethics class three days ago, and one of the questions that we routinely address with these bright, young medical students is: "Would you want to be screened for Huntington's right now, and if you were and you found that your infant was going to have Huntington's, what would you do?" Every year when we do this, it is about 50–50. Half the students don't even want to know, and the other half do want to know. The 50 percent who do want to know, want to know so that they could try to do something.

But when there is nothing you can do, it becomes almost 90–10 with 90 percent not wanting to know. As soon as you say, "But now there is a treatment," then it immediately flips to 99 percent that want to know. Occasionally we have a holdout.

Coates: Were you lecturing at a Catholic school?

Anderson: No. I was lecturing at USC Keck School of Medicine.

Coates: But there is *always* something you can do, and that is the point of my remark: abortion. And this is where we come back to what I call "modest coercion." This is where we are going to have to move to modest coercion.

…the wrongful life suit. All of this information creates an obligation…for individual children to not be harmed by their parents' inaction…

Hughes: I want to agree with that and try out one specific idea that I think will become very common: That is the wrongful life suit. All of this information creates an obligation on the part of parents, providers, states, institutions for individual children to not be harmed by their parents' inaction and providers' inaction to make this testing available and to act on it. Even if very few children actually sue their parents—it may be much more common that they sue the obstetrician or the cytogeneticist—but if very few suits come about, still that obligation is there.

Gregory Stock: I would like to echo something Jeff said and suggest that we think about it a little more deeply. If we are really thinking about 25 years, then none of the reproductive issues we are talking about are very significant for us. What really matters are the kinds of things we can do to adults: the influences and manifestations of our knowledge about biology, genetics, and treatments for diseases. What we really need to be thinking about is genetic profiling and testing and screening, and how that will interplay with treatment and governance. In fact, that issue is what is coloring the larger debate about germline engineering and about all of the more challenging uses we have discussed. What people are thinking about is: What is going to happen when *I* find out such-and-such about *me*? Am I going to lose my insurance? What is going to happen with my children?

Personally, I asked Craig Venter if he would do my genome. I don't care if it is made public. I would love to have all that information. We are talking about genetic tests for one particular disease, but that is not where we are going to go. We are going to be testing for *everything*. There will be some things for which nothing can be done; there will be a lot of things for which something can be done.

…the fact is that we all carry five to ten lethal genes.

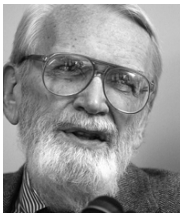
Anderson: There is a problem, and this is what comes out in our ethics discussions with the medical students. It is very brave to say, "I want to know my genome," but the fact is that we all carry five to ten lethal genes. Now, you might be willing to be a pioneer and say, "That's all right; we all have this," but your insurance company doesn't care that everyone is carrying something; all they see is you and that you are carrying ten lethal genes. Your insurance rates have just gone off the wall. Your kids' rates are off the wall. This is what people are worried about.

Gregory Stock: So, the driving force behind genetic testing is going to be insurance in this country.

Anderson: That's correct. That is the second ring.

Gregory Stock: But look at what the driving force is going to be to have testing. If you can go out and spend several thousand dollars and get your testing done, you will do it anonymously and you will buy insurance before you do the test. You will do it in that window of opportunity that you have to find out your genetics before the insurance companies can find out your genetics. People are going to pay a lot of money to do that.

I have talked with insurance companies. The insurance companies don't actually care, and the reason they don't care—it's very interesting—is that they sell their insurance to reinsurance companies, so as long as they are using standard practices, they don't really care how it plays out. The reinsurance companies are another layer, and it will take a while for that to filter in. They have decided that they care more about family history than about genetics.



…the whole notion of tolerating the insurance industry in the future of genetics the way it is today is absolutely bizarre.

Coates: Greg, you are a babe in the woods on that issue. There will be in every insurance policy the statement: "If you have lied, you have invalidated this insurance." But the more important point is that you are both making the incredibly erroneous assumption that we are going to tolerate this insurance company nonsense. I think that what we will have is legislation—back to the governance issue—that says: "Nobody has the right to require a genetic profile; nobody has the right to ask if you have ever had one; nobody has the right to see it."

Now, against those restrictions, obviously we will have to allow a certain number of things; for example, epidemiological studies will be essential—anonymously done. But the whole notion of tolerating the insurance industry in the future of genetics the way it is today is absolutely bizarre. It has to change.

Anderson: It is bizarre now and it will be bizarre in the future. When Representative Conyers put in legislation to do exactly what you are saying was the only time that Jeremy Rifkin and I were on the same page on something, and *Science* wrote it up as a headline: "Rifkin and Anderson Agree." It didn't stand a chance. Now, California does have some protections of genetic privacy, and Europe does. I hope you are right.

Coates: Wait till we get the 500 horror stories about what the insurance companies did, and then we will get the reform. It will be just like the credit card story, where we had to have thousands of people hit with tens of thousands of dollars in bills before Congress wised up and said, "We will do something intelligent." But it is not going to take 25 years even for the Congress to be intelligent.

Jeffry Stock: This discussion is getting into a realm where we *should* go, and that is into the issues of public health and costs. If everybody is going to live to be 100 and the United States government is basically the insurer of last resort, paying for the research and paying for the Medicare, and so on, at some point you are going to have to get a cost/benefit analysis. And at some point in the United States, and it is certainly going to happen in China and other places in the world, you are going to want that information from everybody. You take a blood test, and it may or may not be private, but it shouldn't be private. It would be a tremendous amount of information, and I think that has to happen in order to get the information on what genetics does to people.

You need those databases of genetic information from *everybody*, if you can get it, in order to use that information to figure out what is going on genetically. It has to happen—maybe in 25 years it will.

Palfreman: One way it could happen with the insurance companies is they could say: "You can join my plan if

you are willing to show me your genetic data. You don't have to, but I am offering a cut rate." There is segmentation within the health care market now; everyone is trying to get the healthy people and exclude the sick people. I don't see why this would be any different.

When a whole category of risk becomes known, private insurance as it exists today no longer can work.

Gregory Stock: Insurance is a way of sharing unknown risks. When a whole category of risk becomes known, private insurance as it exists today no longer can work. Joe can say that I am naïve about what clauses will be written, but when you have anonymous testing, nobody will know. It happened with HIV testing, where people would test anonymously. It is going to be very easy to get test results, and that is what is going to spur the changes in the insurance industry. Eventually private insurance will have to go for this particular realm, but that path is not necessarily going to be an easy one.

On the issue of how we share this information: As a replacement for aspects of the drug testing and approval process that exists today, we are going to want that information. It is obviously going to be a battle between individual privacy and the common good, and I don't know how that is going to play out, but it will have a big impact on how quickly these things move.

Coates: When it is universally perinatal, you cannot hide the fact that you have had a genetics test.

Gregory Stock: Correct. But in the immediate future, there are far more adults with diseases of aging and so on. Especially when you talk about life insurance, adults are the ones who will be affected by these implications in the next 25 years. It is not babies.

Jeffry Stock: But aren't most people insured, at least for health insurance, through their work? Nobody asked me; I could be dying; I could have cancer right now, and I get the same health insurance through my work. Isn't that the way it works?

Gregory Stock: Loading up on life insurance is what happened with the AIDS controversy, where there were large numbers of people who bought significant amounts of low-cost life insurance because they knew of the high risk.

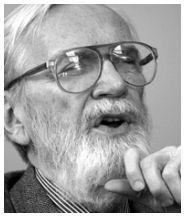
Zimmerman: The insurance problems we are talking about are purely an American phenomenon. If we are talking about the globe, this is a very small percentage. It could be an incentive to reform the archaic and unresponsive US health care system, which is a disgrace. Having lived in Europe under three different national health plans, I can tell you that this is simply a nonissue in most places, where even genetic predispositions, as they have been shown, are not grounds for not giving benefits under the national health plans.

Hughes: There is another reason for that. As medical knowledge increases and the predictability of disease, risk-based insurance will just be impossible. But also the political motivations for having universal health insurance will become increasingly pressing the more the medicine can do for us. If right now lack of health insurance robs you of five years of life expectancy, it will be unsupportable if there is a robbing of 30 years of life expectancy. People will not stand for it. So, there are a limited number of years—within one generation—for private health insurance in this country. Maybe there will be marginal, supplementary insurance, but a package of insurance benefits will be universal for everybody at some point in the next generation.

Jhirad: What about overpopulation as a result of having more people live longer?

Hughes: Personally, I think we are going to stay one step ahead of it through biotechnology. We will be able to feed people.

Zimmerman: What about the rest of the planet?



The theme for this 25-year period should be: "every infant healthy and every child cherished."

Coates: Before we leave the children and infants, I would like to suggest a theme for Jon. The theme for this 25-year period should be: "every infant healthy and every child cherished."

Anderson: That is a wonderful ideal, and as a pediatrician, I can't argue with that except for reality. For example, my wife is Chief of Pediatric Surgery at Children's Hospital in Los Angeles. One of the things that we both find hard to comprehend is that if a premature baby is born in Mexico and it is not of a given weight, at least, it

is allowed to die. It isn't even an issue; they just let it die. If a premature baby is born in this country, people like my wife work around the clock to save it. If every birth in every country is cherished, that is a wonderful ideal, but who is going to pay for all this?

Coates: There are two points on that. One is that your wife's behavior is antisocial; it ought to be declared that, and the rules of her game ought to be changed. We already know that there is a high rate of spontaneous abortion. We know that biologically, through mechanisms we don't fully understand, the body rejects defective babies. So, when you have the two-and-a-half-pound neonate, it is nature crying out: "I should be dead." And it becomes antisocial to save that neonate.

Anderson: It is also murder if you don't save it.

Coates: You are confusing two things.

Anderson: I'm not confusing; I have been accused of attempted murder when I tried.

Coates: You are confusing a legal status with what the social implications are. I am trying to separate those two. The social implications can lead to the change in the legal status. Fundamentally, what your wife is forced to do is antisocial, because she has no way of making clear to those parents what the implications are of saving that two-and-a-half-pound natural reject. It is a lifelong period of travail.

But if you don't like my notion of "every infant healthy, every child cherished," then that should be the thematic goal of one element of this presentation. We want to end this portion of the discussion on the video with something that is extremely positive, that people can resonate with, and that has a lot of plausibility. So, instead of it being "absolutely every infant healthy and every child cherished," the goal we are moving toward is that. We need a wrap-up for it.

Anderson: It sounds great, and it is fuzzy and warm. And I spend my life interacting with parents of kids who have lethal diseases. The fact remains that if a preemie is born and every effort is not made to keep it alive, the doctors involved will be charged by the District Attorney with murder.

Coates: That is the present law.

Anderson: That is the way it is. I've "been there, done that." When I pushed very hard for Nick, who was a thalassemic youngster, when all his systems had broken down and he was there with tubes everywhere, all he had the strength to do was to keep writing me notes: "Please let me die." His family was there crying. For three days he lay there, and I kept saying, "Why can't we just stop doing all these things?" I was told: "You will be arrested for murder if you touch that line." That is reality.

…as we unravel our biology and learn to intervene in realms that were once beyond our reach, we have to be willing to draw lines…

Gregory Stock: That is a great example. It captures the essence of what we are trying to get to in this period: our image of ourselves, what it means to be human, and who we are. We have touched upon it in a number of ways, but what we are really getting at is that as we unravel our biology and learn to intervene in realms that were once beyond our reach, we have to be willing to draw lines—both at the end of life and at the beginning of life. That is something we are finding exceedingly difficult to do, and it confronts all of the issues of religion, personhood, and the value of life. These are the things that we are going to be facing. That example is a perfect one that captures that collision, and there are a number of them at the end of life too.

Palfreman: In terms of the constraints that would cause us to draw lines, clearly the cost of medicine is one. Over 25 years, it is something like 18 percent of gross product, and it has been going up. A staggering percentage of money in health care goes to the last few weeks of life. Is there a sense, French, that over this 25-year period we will confront issues like that?

Anderson: Oh, we have to! I totally agree. There is no way that our society can continue the way it is. It has to change. Now, how is it going to change? Unfortunately, the way it usually changes—the analogy was made with the credit cards: thousands of people with thousands of dollars until finally Congress stepped in. Sooner or later, it is going to happen when the number of horror stories becomes so great, things will change. But I don't know how or when that is going to happen.

Coates: The next time a case of thalassemia comes up, commit the murder, go to trial ….

Anderson: Thank you very much. You remember at the UCLA Symposium, I was under attack by James Watson, and Watson basically said the same thing: "So some people die; what difference does it make; why are you going to listen to a fundamentalist …?"

Gregory Stock: Yes. We have come to the point where there is no way of escaping these decisions. We simply

can't afford to do everything. When we started doing dialysis, nobody had an idea that this would consume the amount of medical resources that it does today. There are many other conditions where that is going to be the case, so we are going to be forced to make these decisions. We are going to *have* to come to grips with it, and it is going to be the most challenging thing that we are going to be dealing with, not germline engineering or those other near-term issues.

Western medicine tends to be heroic…The low-key, common-sense methods are not considered macho enough…

Andreadis: There are three items that impinge on a lot that we have said. One is that it is not so much the cost, though that is a tangible thing, but it is the quality of life you are giving to these people if you extend their lives with tubes coming out of all parts of their bodies.

The second is that if you look back and see what made the hugest difference in health—what made people's lives go from an average of 30 years to an average of 70 years, the answer is clean water and antibiotics. Those are low-tech compared to this. Western medicine tends to be heroic; it is a heroic intervention model. The low-key, common-sense methods are not considered macho enough; it is not heroic; it is not a "cowboy" thing to do. You just go around and give people iodine, and you prevent cretinism. You just put iodine in the water and that is good enough. In this case, when you are asking about quality versus the heroic intervention, that is also a public policy decision.

Some of it has to do with common sense, because American law, unlike European law, is based on individual precedent, and not on commonly accepted principles whereby you can go to the end of any logical decision and keep building on that. So, you have a complicated and rather creaky machine that has developed in this country, which causes Europeans to say: "Those Americans! What can you do?" We accumulate and use a disproportionately huge number of resources here for all of these individualized cases, where elsewhere they deal with them on the low-key levels and take care of them. So, some of the things we have said here today are applicable on a wider basis, but some of them are America-specific.

Zimmerman: A lot of them.

If the government and the court system lose jurisdiction over the use of this technology, then who picks it up?

Campbell: One other point on that: If the government and the court system lose jurisdiction over the use of this technology, then who picks it up? Whom does it default to? Does prerogative go to the family? Does it go to the individual? The question is: Who is going to be in charge of this new technology, especially germline engineering?

Fowler: It is going to be very difficult with these technologies to have any kind of regulation, because that would tend to criminalize these actions. I think that Americans, at least, and people generally are looking for self-improvement of one kind or another. But to criminalize methods by which we reach self-improvement is the only way by which we are going to have any kind of regulation at all. There is no soft way, in my opinion, to go about regulating the use of these technologies. It is going to have to be done by consensus, but there will have to be some way in which societies can form to make decisions about the roads they want to go down. But when they do go down those roads, then we can't criminalize the roads that we ultimately take.

…there will be an increasing differentiation…between those who think that what is of value is humanness qua humanness…versus those of us in bioethics.

Hughes: I want to touch on something Greg Stock said about the fact that through many of these controversies we are going to be facing, there is the issue of what is of value in a human life. I think that is one of the conflicts that will start in this generation and carry through to the next. We see with Kass, Fukuyama, and Catholic social ethics that there will be an increasing differentiation in our body politic between those who think that what is of value is humanness *qua* humanness—the human body, the fetus from the moment of conception through brain death; just having that physical constitution is what is of value—versus those of us in bioethics. It is implicit in democratic theory since Locke to think that what is of value in the human condition is having a

self-awareness and that what gives moral meaning to life is suffering, ability to make decisions.

Those of us who have *that* point of view have a very different approach to how we deal with the ethics of the fetus, ethics of the brain dead, ethics of animals, ethics of posthuman enhancement. All of these issues are strung together by that thread and will become, I think, what I have referred to as bio-Luddites or bio-conservatives versus the transhumanist dimension of the future. I see that as an issue at least through the next ten generations.

Zimmerman: To inject some considerations in formal ethics or in bioethics, which to a large extent underlie the laws we have in this area: You have the principle of autonomy, where the individual or the parents make the decisions; you have the question of distributive justice: Whatever is available for a benefit should be available to everyone; you have resource allocation, which gets into the question: Should the government pay, for example, for end-state renal dialysis for everybody? That law, by the way, was the result of lobbying by the dialysis industry.

So, you have all these competing ethical values, all of which have their own validity or justification, but many of them are in conflict with each other. The way society deals with these is not easy at all. Then on top of that you have the moralists and religious people who want to impose their will on everybody else. I throw this open only as a relevant point of discussion for this forum, rather than to propose a solution.

Andreadis: That brings us into the next generation. Is it a question of the overpopulation or the fact that in the old days if you disagreed with somebody, you said, "I am going to take my disciples and go to Massachusetts. There we will build the city on the hill, and nobody will interfere with us, and we will burn witches, because that is what seems appropriate to us." Nowadays it has become impossible. We *have* reached the planetary level of integration, one way or another, with all the kinks. At this point, you cannot go anywhere and do the "city on the hill" business.

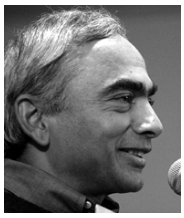
So, one additional complication that was not true even 20 years ago is that now when we deal with this, it has to be dealt with globally. The question of overpopulation has to be dealt with globally as well, because although it is true that you can take care of feeding them, are you going to have basically wall-to-wall people? There will be no grass; there will be no animals; there will be no place where people have not been before? How are you going to give them the will to live afterwards? What are they going to aspire to except cyberspace?

…the most dangerous thing is to have global solutions…

Gregory Stock: You mentioned not being able to go elsewhere because of the level of population and habitation, but still there are very different regulatory environments in different regions. It seems to me that the most dangerous thing is to have global solutions because of just that fact. People *can* migrate to regions that have a more amenable environment to the values that they espouse.

You can see that with reproductive technologies, where there is great diversity. You can see it with the therapeutic cloning debate; there is a big debate going on in this country, and yet it is somewhat irrelevant because the issue is moving ahead rather aggressively in Singapore and elsewhere. Some of the most difficult, most painful issues arise because we make abstract global decisions that create situations like French was describing, where actually everyone involved knows what they want to do; they see the pain that is involved; and some other agency is saying, "That may be the case, but that suffering is okay because of the larger implications." You can't draw these lines. We are going to have to make more individualized decisions, and that is very painful for those who want to generalize.

Kirk Citron: You started by painting a picture of, within one generation, being able to cure all these diseases, solve all these problems, and extend life expectancy to 100. My question is: How much of all the things that have been talked about here are going to spread how broadly across the globe in one generation? If you can cure all those diseases, it doesn't mean you are going to have the money or the technology or the will to spread that to six billion people. Can you talk about how much of what you have talked about is going to spread how far?



But the fact of the matter is that there is a food divide; there is a clothing divide; there is a shelter divide; there is a bicycle divide…

Velamoor: I come from that part of the world where these divides exist. Somebody brought up the issue of the digital divide—a conversation about how there is such a huge gap in the availability of computing in the Third World—and I pointed out that we are talking about a digital divide and I imagine it will be the case with somatic gene intervention divide. But the fact of the matter is that there is a food divide; there is a clothing divide; there is a shelter divide; there is a bicycle divide; there is a television divide. These divides will continue, I imagine.

In theory, gene therapy should be —in another generation—as inexpensive as a shot of penicillin or a shot of insulin.

Anderson: There is no question that there is an enormous gap between the developed and the developing (or underdeveloped) countries. One of the reasons that gene therapy received enormous government support at NIH and the Department of Health and Human Services was because, in principle, gene therapy could become as inexpensive as antibiotics.

The only thing I disagree with in what Athena said is that the two big things that make a difference are clean water and antibiotics. Well, antibiotics is high tech, in a sense—not now, because the market is so big that now you can make penicillin very cheap, but originally, in 1950, penicillin was expensive; it was high-tech stuff. In theory, gene therapy should be—in another generation—as inexpensive as a shot of penicillin or a shot of insulin. So, it *does* translate to Third World countries, and that is one of the social reasons that it has had such enormous support.

Gregory Stock: The idea that gene therapy would become cheap is not intuitive to me, considering that it would be tailored to individual problems and there is a great deal of technology involved in any interventions.

Anderson: Yes and no. The big push right now is for oncolytic viruses to treat cancer, and that really isn't tailored to individual patients. It is tailored to the cancer, so something that is tailored to lung cancer is going to be applicable to millions of people.

Jeffry Stock: What about infectious diseases? We haven't even touched on that, and that is the major cause of death in the world.

Anderson: The first gene-therapy treatments approved by FDA to be sold as treatments will probably be vaccines for infectious disease and/or cancer. The majority of the Phase 2 and Phase 3 trials in this country—well, in fact, around the world—are specifically vaccine-based and specifically for infectious diseases.

Coates: Before we break up, I would like you to address three questions: One is human cloning. The second is multigenetic disorders. The third is mental functions, not just intelligence or disease.

Anderson: The cloning one is easy to take care of. Mental function is beyond our one generation; we can talk about that when Greg [Stock] talks about ten generations. The multigenetic diseases: We are healthy because our genes provide a defense system, and that defense system has evolved—it is an evolution issue. We still have the genes of the nomad who was out traveling the plains. When we talk about adding genes to correct a disease, we usually talk about monogenic diseases, because that is easier. Sickle cell anemia we can understand.

In cancer, as I assume most people know, that isn't one gene that goes bad. Colon cancer is anywhere from eight to ten. There are a number of cancers now where the number of oncogenes that have to be activated, the number of tumor-suppressor genes that have to be knocked out, is somewhere in the range of eight to nine to ten. What that means is that it isn't a single gene. By definition, every non-monogenetic disease is a multifactorial disease, a multigenetic disease. But it should be possible to determine which gene is not sufficient or is overexpressing to be able to either shut down the more dominant gene or increase the less dominant gene. If you do a systems-biology analysis, you will find one gene that is more dominant, and therefore it is treatable.

One broad answer is that in many cases it will be a single gene that will be helpful, but secondly, we can put in genes. We routinely make vectors with three genes separately expressed. In time it will be possible to do four, five, six, or seven genes. That is doable within our one-generation framework.

My personal opinion is that human cloning is based on the wrong assumptions and is, in a sense, stupid…If you make a hundred clones of a given human being, you are going to have a hundred different personalities.

Now, human cloning: My personal opinion is that human cloning is based on the wrong assumptions and is, in a sense, stupid. The assumption is that if I want to reproduce myself, I clone myself. Well, all you have to do is look at identical twins. In fact, all you have to do is look at Siamese twins—the two that were attached at the heads. They had totally different personalities. Now, you can't argue that they had different genes; you can't argue that they had different environments. They were attached by their heads; they had the same environment; but they had totally different personalities. If you make a hundred clones of a given human being, you are going to have a hundred different personalities. The reason for cloning, if it is based on ego, is stupid. If it is based on parental feeling that they lost a child and simply as a spiritual feeling of trying to continue that child, even though they know it will be a different child—I can see the emotional basis of it.

Coates: But those are your opinions about it. What is your judgment in terms of a forecast? Will there be any significant number of people at all who will be subject to human cloning?

Anderson: I don't think so.

Coates: So, you think it is a zero category.

Anderson: Nothing is zero. I think it is impossible to legislate zero percent of anything. If somebody really wants to do it, they will find somebody in some other country, some offshore island, some doctor who will say, "For a million dollars I will clone you." It will happen, but it will be on the fringes. You can't make public policy based on fringe issues.

Andreadis: In fact, its repercussions will be much lower than we think, not only because they will not be identical and will, in fact, be given full citizenship rights, but because you haven't done anything new scientifically. We have done cloning. It is around; it has been with us; we have done it. If we do it for humans, it is just something new socially.

Coates: But think of Jon's problem. That is not an answer that is satisfactory for Jon's problem to say, "There is nothing to this; it has been around; we know all about it." It is an issue that is in the public discourse, and it seems to me that it has to be addressed in a way that Jon can use.

Cloning has become extremely important as a symbol, because it is emblematic of our potential to delve into our own biology…

Gregory Stock: I will give you an answer to it. Cloning has become extremely important as a symbol, because it is emblematic of our potential to delve into our own biology and to do things that have not been done before, and because reproduction is such a sensitive part of our image of ourselves and of our purpose in life. That is the key to cloning, not that it is going to be broadly used or that it is scientifically important.

Zimmerman: There may be a technical reason why this isn't even a very viable technology, all the other considerations notwithstanding. If we tried to derive all the cells in a body from a single adult cell, there is a probability that there will be a number of fixed mutations in that one somatic cell nucleus, which is perhaps why the percentage of successes in animal cloning is so low. This is a very different story from something derived from germ cells, where there seems to be a protection against these mutations. In a tissue where all the cells are different, you can accommodate a certain mutational load because the tissue still functions. But if all the cells are derived from a single adult nucleus and contain identical aberrations, the chances are you will have a big problem.

…technically we will be able to do many marvelous things in one generation, but the real issues are going to be legal, ethical, moral, social, political, regulatory, economic…

Anderson: Just to summarize this session: What has been said is that technically we will be able to do many marvelous things in one generation, but the real issues are going to be legal, ethical, moral, social, political, regulatory, economic, etc. It gets down to the basis of this Foundation: to think about where humanity is going and not necessarily to say where it *ought* to go, but at least to start comprehending what the issues are that are involved in where we are going.

Palfreman: Thank you. That was a perfect session.

Major Issues Session II

Ten Generations (250 Years)

In this session, the scholars endeavored to address what the major scientific and technological advances will be in the next 250 years and what impact they will have on humankind.

Discussion Leader: Dr. Gregory Stock

Is the length of human life going to change in such a way that we will be developing life plans relevant to significantly extended lives?

Gregory Stock: Ten generations is a long time—250 years. Given the rates of technological advance that seem to be occurring today, unless there is an inflection that occurs so that we go into an "S" shape of some sort, there are going to be enormous developments within that period.

We ended the last session by looking at some of the challenges we will face about what it means to be a human being. Those will be mere prelude to the more fundamental changes that we will be bringing both to our environment and to ourselves in the generations beyond. I will trace some of the areas that I think are the most interesting and challenging ones; then we can focus on them individually.

One of the most challenging areas for our image of who we are is longevity: Is the length of human life going to change in such a way that we will be developing life plans relevant to significantly extended lives? What is that trajectory? The second area is reproduction: Is there going to be a complete separation of reproduction and sex? To what extent is our technology going to be infused into that process? This is critical to our view of ourselves.

The third area is our emotions: whether we are going to develop nuanced and precise enough pharmacological influences on our emotions to short-circuit the ones that channel our behavior toward certain types of activities. If we can gratify ourselves relatively easily in various ways and short-circuit those evolutionary mechanisms that caused us to struggle to achieve those feelings, what does that mean about why we do what we do?

Is nonbiology going to transcend us and be the cutting-edge of life, of thinking, of consciousness and creativity?

Those are three areas, and underlying them is the issue of biology and nonbiology. We know how rapidly nonbiology is moving ahead; we have an idea of the potentials of biology as well. What is going to be the intersection between the two? Are we, in fact, going to become cyborgs, with increasingly nonbiological components? Is nonbiology going to transcend us and be the cutting-edge of life, of thinking, of consciousness and creativity? Or will we remain biological creatures surrounded by a sphere of very enhanced devices of different sorts?

There are also issues of enhancement and therapy, but I think these three are the technological possibilities that are most important for us to discuss. Others may come up. By *enhancement*, I mean all the other aspects of biology like intellect, resistance to disease, physical potential, and so on. I think longevity is a very important one. Who has thoughts about the possibilities in the next 250 years for impacting the biology of aging and human longevity?

…is longevity simply a question of maintaining the meat puppet, or is it a question of maintaining identity across time?

Hughes: One of the questions we have to address there is: What is the thing that is surviving? In discussions about cryonics, for instance—if cryonics were ever to be successful, if we had a nanotech bath that we could dip the frozen "corpsicle" into and reconstruct it—some

people ask, "What is it that is being reconstructed? Is it the same person?"

To give you a more specific example, I think that we are already in the steps of Kurzweil's projection of a nanotech-based set of brain augmentation, brain prosthesis. You have seen the guy with wires in his head running out to a video camera. You have seen Roy McKay's work, where a person can move a cursor on a computer screen by just thinking the correct muscle movements in his head. We extrapolate that, with the extrapolations of Moore's Law, with the eventual development of nanotechnology. Not within one generation, perhaps not within two, but within ten generations, yes, we are going to have those kinds of brain augmentations.

Then the question becomes: If we can share our personal identity across a set of platforms, biological and nonbiological, is longevity simply a question of maintaining the meat puppet, or is it a question of maintaining identity across time?

Gregory Stock: Let me focus that more, because we are going to get into the issue of nonbiological content later. What will be the life expectancy of a child that is born in 100 years?

Hughes: Their body or their personality?

Gregory Stock: I am assuming, for purposes of this discussion, that there *is* going to be a biological component and that the persistence of that is central. You can have any sorts of enhancement that you want, but if the biological portion of your brain goes to mush, then as long as you are biological, you die. Cryonics just delays that notion, so it is not terribly interesting in terms of our time frame. Let's talk about biological life spans.

Coates: Isn't there an interesting question that would shape that, though? Namely, why would there be any desire for substantial longevity? I am not talking ten years or 15 years, but what would be the desire for 125 or 150 years? If we don't understand that, how can we talk about it?

Gregory Stock: We will get to that in the second section, where we deal with the influences in these realms. Let us assume that there are sufficient driving forces to create a desire. I believe there *is* a strong desire for an increase in health span, but first, let's talk about technological feasibility.

…our synapses are us…you cannot discuss longevity unless you discuss how you are going to preserve your mental functions.

Andreadis: Connected to what J. Hughes was saying, I would define *longevity* as the continuity of consciousness. That is, you still know that you are Person X. There is a reason for this: Our neurons don't renew. If you get significant rearrangement of your neurons—for example, if you have a stroke—you can have a significant change of personality, sometimes to the pleasure of your spouse.

There is always an inherent dualism to phrases like "the meat machine." You are implying that there is a ghost in the machine that is hovering around here that is not part of us. In fact, our synapses are us. If you go into a cryonic state and your synapses don't survive, it doesn't matter what comes out on the other end. You yourself, as an individual, as a person, are your synapses, effectively, and these are part of your "meat machine"; they are not separate things. There is no *anima* or *élan vital* there. You are your body.

The bottom line is that you cannot discuss longevity unless you discuss how you are going to preserve your mental functions. It is not just repairs of your lungs; repairs of your liver; but how you are going to take care of the brain.

Gregory Stock: That is certainly essential. A brain in a bottle, if it is conscious and has extensions, is you.

Why do we want a body? …how much beyond the brain do we want to sustain?

Jeffry Stock: So, why do you need a body? Why do we *want* a body? It seems to me that if longevity is important, the one thing you want to do is minimize the possibility for accidents. It already is becoming a tremendous issue—everybody is going around in helmets. J. Hughes spoke earlier that we might have fetuses in tanks. If you can do that, you can have your body enclosed in something … this idea of an isolated brain. If it is connected, you don't really want to travel. We don't have to travel that much right now, with what is happening with tech-

nology. So, how much beyond the brain do we want to sustain?

Gregory Stock: Are you suggesting that within the next 250 years there will be the potential for having essentially a disembodied brain that is protected in some environment?

Jeffry Stock: Not necessarily. But even now people are getting replacement parts. Your body becomes less important after the age of 80, let's say. You want to maintain your body to support your brain—right? You have to watch out for infectious disease, for all kinds of problems, for accidents, so you want to minimize your actual physical contact with other humans, if that is true. Probably, in 250 years, you will be able to get from various drugs or other modes most of the satisfaction that you now get from those.

Anderson: How depressing.

Palfreman: Some of these ideas sound like 40-generation ideas. Can we stay with ten-generation ideas?

Gregory Stock: What we are getting at is that the preservation of mental function is critical to the idea of the continuity of self and extension of self. Now there are inputs coming from the body and there is degeneration. Let's look at the fundamental process of aging and controlling that process as the first level of the discussion. Who has thoughts about that?

I see the limit of life as the storage quantity the brain can take, and that is definitely limited.

Walter Kistler: As probably the oldest person here, I may be justified in making a remark about these ideas on body versus brain. The first question is: How can we extend the health of the body so that we live longer? The second question is: How can we support the brain? Often when I was younger, I wondered: What should I try to achieve when I get older—rather a healthy body, so I can still walk around and be in nature, or a better brain, so I can still do my work, write a book, or whatever.

Now, as I get older, I find out that the body is not the problem. If you have reasonably good genes, you can keep your body in good shape. I was supposed to have a hip replacement 12 years ago, but I just kept exercising and kept my body in good shape, and no hip replacement was needed. So, in my view, since I have lived many years, it is not the body that is the problem; it is the brain.

The brain is like a big storage system. It stores all your experience, all the things you learned in life, and it has a finite capacity, like any storage system. When you get around my age, over 80 years old, you clearly realize that there is a limit to the storage. If you cannot learn new things or remember much what you did, life becomes very uninteresting. I see the limit of life as the storage quantity the brain can take, and that is definitely limited. For somebody who has had lots of experiences, learned a lot, done a lot—when he is past 80 or 90, that is about the limit. After that, he hardly remembers what he learns or reads; he hardly remembers because there is no more space. There is nothing you can do about that except eliminate the synapses, and then you are no longer yourself. There is nothing new to do, to learn. I think there is an absolute limit there that is a given. Like any storage system, it is full and that is it.

Gregory Stock: There is a continual process of remembering and forgetting, and the functioning—the actual dynamics of the brain—are changing constantly through life. Athena, did you want to comment about that?

Andreadis: There is no question that your brain has capacity and it does keep changing; that is how you do new learning. There is also no question that you have an absolute storage limit, but that is why you forget things that are not necessary or are no longer necessary.

Quality of life has to be human relationships and the ability to be involved with your environment by learning and doing something useful.

Anderson: I have to respond to Jeff Stock and also to J. Hughes, who keeps referring to me as "shackled to the 20th century" instead of moving forward. To me, human existence has two critical components: One is exactly what Walter said: the capacity to learn to do something, to accomplish something, to be involved. And the second is human relationships. Without human relationships—maybe I am 19th century—but without human relationships, what is life? So, my brain is in a tank and it has drugs so I feel … whatever. To me, that just isn't life. Quality of life has to be human rela-

tionships and the ability to be involved with your environment by learning and doing something useful. Without that, I don't see that there is a quality of life.

Gregory Stock: Let me mention something to help get at the technical issues. A lot of people are talking these days about the idea that we will understand the biology of aging; that we will be able to intervene and retard those aging processes; that we will be able to delay the diseases of aging—like Alzheimer's, cognitive dysfunction, and heart disease; that we will be able to double or triple health span. Are there thoughts about the reality of those ideas within the next couple of hundred years?

Andreadis: You probably have heard the question: How do paradigms change? The answer is: When the believers of the old paradigms die. The bottom line is that if you have people around who are 150 years old, it might be an interesting inflection point for progress. These people, who are going to be powerful and strong and experienced, will have certain thoughts about how things are to be done. If you double life span, you are actually going to impede the thing that you are trying to implement for progress.

Gregory Stock: So, you have the irony that the most radical development in the history of humanity is the most conservative and would impede further development.

Hughes: Except that the people who survive the longest are going to be the ones who adopt this technology; the ones who die off will be the ones who are against it.

Gregory Stock: Athena is saying that most change in society comes from the dying off of a previous generation that is more comfortable with the existing way of doing things. If people live longer because they adopt and embrace this technology, they will remain in power, comfortable with the way things are.

Velamoor: The life cycle of paradigms keeps extending.

Hughes: I will agree with that. To go back one step, I also agree that one of the questions is: How much longer can the meat puppet live? But does anybody really suspect that we won't have further progress with brain augmentation and the direct communication between the brain and computing technology that will overcome the kind of constraints that Walter was talking about? Does anyone reject that? You reject that, Joe? Tell us why.

Gregory Stock: Wait. We're getting off track. For the moment, I want to stick to the question of anti-aging, of extension of human life span.

Palfreman: Can Athena speak to that? It seems to me that we have raised this question: What is the likelihood of neuron protection to greatly extend life expectancy?

You learn something about the molecular level in gene regulation, but that does not transport to the level of the whole organism.

Andreadis: Right now and in the foreseeable future, I would go for a ten-percent increase. That is what I see in the near future. In ten generations you might have a 50-percent increase, but the question always is "if—then": If you can take care of the neurons; if you can keep your brain neurons well. If you can do that, I think you can do the 50-percent extension.

There was an allusion earlier to the fact that we have extended the life spans of Drosophila and so forth, but what is interesting is that on the molecular level, things are very similar. That is an odd thing in biology. But as you go to the organismic level, things start to diverge increasingly. So, what works in Drosophila in extending their life span is not going to work for humans. You learn something about the molecular level in gene regulation, but that does not transport to the level of the whole organism.

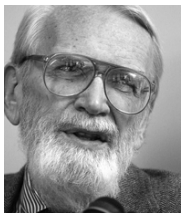
Coates: Isn't Drosophila only 30 percent, though?

Andreadis: It is about 50 to 100 percent, actually. It was significant. You can actually breed it.

Gregory Stock: You can do it with a single gene.

Coates: But when you say 50 percent, you are talking about moving the set point. You aren't talking about everyone living 50 percent longer; you are talking about moving the biological set point. Right?

Andreadis: Yes.



Are we going to have differential aging so that in fact people are not better off; they just rot in a different pattern?

Coates: It seems to me that the question we haven't addressed is: If we had this life extension, what will be the pattern of differential aging? In spite of the fact that

we may be able to alter the rate of aging through a variety of techniques, are livers going to be as susceptible to improvement as esophagi? Are toenails going to be more or less susceptible, compared to medullas? Are we going to have differential aging so that in fact people are not better off; they just rot in a different pattern?

My second point is: Assume things work well and we have a kind of "stretch-out" in life, can you imagine anything more dreadful than being 17 years old for five years, 14 years old for five years, 12 years old for five years? Imagine having teenagers for four times as long as we have them now! Would there be a social advantage to that? Would it be an advantage to the teenager? The point is: What is going to be the pattern of the extended life? Will we be old for 20 years instead of old for ten years? Will we be infants for ten years instead of for three years?

…there is nothing now in neurology that says that it will be impossible to…purge the memory, purge the storage space…and allow for replenishment…

The other point on the brain business: As far as I know, there is nothing now in neurology that says that it will be impossible to, so to speak, purge the memory, purge the storage space, keep certain kinds of things and allow for replenishment of the interesting memories. The reason I can say that is we know so little about how memory actually works. For example, I am thinking back to my 12th grade school, and I have a picture of it. Nobody now knows, neurologically, how I assemble that image and use it. Now, when we figure out how those images are created and assembled in memory, it may very well be that we will be able to purge the system and leave fresh space. So, I am not as pessimistic as Walter is about the storage box being overloaded.

It seems to me these are two questions we have to look at: Can you replenish the mental capacity by rollover, by purging? And second, how will this life extension affect the various stages of life?

Campbell: One aspect of the question is quantitative. How profoundly has the 50 percent increase in life expectancy over the last 100 years affected our society? I don't see that that has been a crucial factor in the advancement of society, and I don't see why another 50 percent will now suddenly have tremendous effects. A two- or three-fold increase in longevity might have a big effect, but if we are trying to pick out factors expected to profoundly affect us in ten generations, I don't see that a 50-percent change in life expectancy is one of them.

Andreadis: I have to disagree with you on that.

Jeffry Stock: That is what I was just going to do. The way Western man, which is what John is talking about, looks at life and lives his life is very different from the Third World, where you can find life expectancy of 20 or 25 years. It is a very different kind of culture, very different way of looking at life, very different reproduction; everything is different.

Velamoor: But what John was saying was in answer to Joe's question: Will the different stages of life materially change? He is resorting to history to ask: Have they?

Andreadis: The answer is: Yes, they have. First of all, humans are relatively unique in that they have an extended neoteny. We have a learning period that is much, much extended compared to other primates, let alone other mammals. We keep actively learning. If you read the way people behaved and reacted—read *The Iliad*—their life spans were, what, 25 to 35? They behaved very differently from us. There is no question that an increase of human life by 50 percent would change the behavioral patterns.

Campbell: But you are talking about more than 100 percent change. You are comparing 35-year life expectancy with today's 70+. That is 100 percent. I agree that if we start doubling the life expectancy or tripling it, then it is a different matter, but you were talking about a relatively small amount.

Andreadis: No, I was talking about 50 percent.

Campbell: So, how long ago was our life expectancy 50 percent lower in the United States?

Hughes: A hundred years ago.

Campbell: Are we that fundamentally different in the way we look at things from 100 years ago?

Andreadis: Yes, we are. I would argue that we are.

On the subject of purging the memory: We do know something about how memory is made and stored. We don't know everything. We don't know where your grandmother's picture is in your brain, but we know where it resides. It resides in your synapses. Long-term memory is in your synapses. So, if you want to purge your memory, it is like burning this village in order to save it. Which synapses are you going to purge?

Coates: You are correct; I agree with you completely that the memories are in the synapses, but that doesn't tell very much. That says only that the water is in the rivers and the oceans. It doesn't tell much about how they flow. The thing we do not have a theory of in neurology

today, unless I am incredibly off base, is how the various stored elements of a picture are drawn back together. When I look at that kitchen, I do not store that full picture at a specific site in my brain. It is broken up into six or eight components stored in different parts of the brain. We don't know how that is done. Secondly, we don't know how that is reconstructed. Tomorrow, if I think of that kitchen, I will have an image of it, and no one understands how that is put together. That is the critical issue we have to deal with.

But you really messed up on the numbers about this doubling of lifetime. A hundred years ago when life expectancy was 40 years, we still had people who lived to be 60, 70, 80, 90. The reason the average life expectancy was half of what it is today is for one reason. We lost a large number of expendable people, called infants and children, to disease. They were not productive members of the society. Second, we lost large numbers of young women in birth. We lost other large numbers of people from industrial accidents. But the notion that somehow we were not a society with large numbers of old people is fundamentally incorrect. Because family sizes were so much larger, most families grew up with a large number of people spread over the whole age spectrum. In that sense, John is perfectly right that we haven't had that much change. Families have shrunk; people are living longer; so we still have exposure in our development individually to a full spectrum of all ages. The notion that somehow or other we have major behavioral changes because life expectancy has doubled is an error in the interpretation of the death rates.

Gregory Stock: There is basically a very conservative view of what is possible, it seems, in terms of the extension in human life span. Some people are saying that we might be able to do 50 percent, but we could not do tripling. I think that within the next generation, we will have an understanding of what is feasible and how hard the problem is, but at this point, we really can't make a statement, and it feels rather arbitrary and *ad hoc* to say, "Well, maybe we can add 50 percent but not triple it."

Walter Kistler: If people would live twice as long, or even 50 percent longer, that would be an awfully boring situation. It would be boring for themselves, because in spite of what you say—you can clean up the storage; you can make new storage—if you clean up the storage, it is no longer yourself. You would like to be yourself, with all your experience, all your memories, and you would like to run new ones, but you are limited and you cannot run more. So, life becomes definitely boring when you are over age 70 or 80. I know. Second, all these old people become boring for the young ones.

No other culture, it seems to me, ever looked at children as so valuable as we do.

Jeffry Stock: One thing I have noticed just in my lifetime is the difference in the way we view children. Now in our culture, it seems that children are most valuable people. For example, the antiabortion group: to kill a child is a great tragedy, because that is an empty cup that presumably would rise to great things. Whereas to execute a 40-year-old man who happens to have made a mistake and killed someone or to have done something crazy is perfectly okay, because he has already lived. No other culture, it seems to me, ever looked at children as so valuable as we do.

That feeds into what I was saying about our view toward our bodies. Now there are laws that children have to wear helmets; they have to be protected because they are so important, because they are going to be the recipients. If you have a guarantee that you are going to live to be 90, you don't even want to ride a bicycle. It used to be, when I was a kid, I would hear: "Go play in the street."

My father said that when he was a child, which was in the 1920s, every woman would talk about: "I have a family. I have two children living and two dead." In the Old West, it was more of a crime to steal somebody's horse than to kill him, because he could die the next day of some infectious disease. In 1945, the major cause of death in the United States was pneumococcal infections. Now it is heart disease, and it is a totally different picture. I think things have changed dramatically.

Campbell: My impression is that the rest of the world sees us as much less protective of children than other peoples—say, the Chinese and the Australians. I don't think that we are the paragon. You speak about having to wear a helmet—well, that isn't just children; adults have to have helmets too. Kids have to be strapped in when they ride in a car; adults have to have that too. My feeling is that we are short-changing our children more and more. What percent now are in poverty? I really don't think that we, as a society, hold children in higher esteem than the rest of the world or than we used to hold them.

Coates: Both of these things are happening at once, because privately your child has zero economic value. The only reason you have children is to be a living

extension of your own ego. You want them to be the best one around. Therefore, you take a great deal of care for them. But they are *your* children. Other people's children you don't care about at all: cut educational budgets, cut food, cut maintenance support. You can take care of your own little gems, and let the society take care of the rest of them.

Jeffry Stock: Actually it has changed. What you are saying is correct in a way, because in a Third World country, your children are more important to you because they are going to take care of you. But right now, my children aren't really that important to me, because I don't depend, in my adulthood, on my children. So, it is the society that says that children are important, but for the individual, the children maybe aren't as important. It is not so vital.

Gregory Stock: Let's go to the issue of emotions. What kinds of drug control might there be over the various emotions we feel, and what will the impacts of that be? First of all, the technological question: Are we going to be able to have cocktails of pharmaceuticals that shape our emotions, that can buy us contentment, that can arouse us sexually, that can create all sorts of feelings that we might consider desirable? Does anybody have any thoughts about that?

Palfreman: We *are* talking about 250 years. Currently the state of psychiatry, as friends of mine well know, is terrible from the level of science. One of the reasons is that with SSRIs [selective serotonin reuptake inhibitors], you get terribly poor data. When you try to compare it, it barely does better than the placebo group, and it is argued that genetic variation means that what might work for one group would not work for another.

Potentially within 250 years we will understand this genomics well enough so that you can say, "This particular drug will have this effect on you, but it won't have this effect on Jeff." It is conceivable, but we start from a very low base. I am totally unimpressed with what has happened so far. It seems to me that it is a complicated issue. I would be interested in what Athena says, from the neurobiological point of view.

Andreadis: You are absolutely right. However, in 250 years what may be feasible—and, incidentally, this is also true for things like chemotherapy—is to have personalized cocktails. It is like blood groups, but more fine-tuned: If you belong to group "A1c," then Prozac is your turn-on (or turn-off or whatever). I think that is feasible, probably—not personalized individually, but personalized by group.

…I am perfectly confident that there will be complete control of human emotion by that point…

Hughes: The conservatism of saying, "Within 250 years we *may* be able to have personalized cocktails." You are the physicist or biochemist; I am the sociologist, but I am perfectly confident that there will be complete control of human emotion by that point, and that the questions we will face at the point will be different kinds of addiction and different kinds of questions of existential meaning to a life in which one is able to control every aspect of one's sensorium.

If you are able to live, for instance, in a complete virtual reality without any physical experience, what will be the meaning of those kinds of lives? Will we tolerate those kinds of lives? If one can have a perfectly satisfied life through inducing various kinds of pleasure centers, will we allow people to do that? Already we have those debates. I think the questions will be much more profound. We already are doing the testing for SNPs [Single Nucleotide Polymorphisms] to determine the different kinds of drug sequences that are applicable to different people.

Andreadis: It is worth pointing out that there are two types of emotions. There are the emotions that are your limbic system: fight, flight, food, reproduction. Those bypass your cortex. You cannot think about them; it is not "by committee"; you have to react immediately, otherwise something will eat you.

The others cannot be distinguished from thoughts; they go through the cortical committee, and it decides what you are thinking and it makes the choices for you. Those are much harder to deal with. The other four, I agree with you: already we can take care of those, to some extent.

Gregory Stock: But also, it is not changing the emotions, but being able to evoke those feelings of pleasure or fear. It might be taking a pill that makes a person happy to be who he is, doing what he is doing.

Andreadis: Yes. The pleasure centers can be easily stimulated. They are "primitive"; they are part of the reptile brain, in some ways. The others—the ones that make you creative, the ones that make you think important thoughts—that is a different story. They go through the cortex.

What about modifying the limbic system, the seat of emotions, genetically?

Zimmerman: Carrying this past the point of pharmacology to possible genetic modification: In 250 years, we may understand enough about brain structure and its connection to genetics to be able to do germline enhancement of brain function. What about modifying the limbic system, the seat of emotions, genetically? I think a strong argument can be made that much human behavior really rests in the limbic system and not in the cortex—things like competition, male/male rivalry, aggression, all sorts of things that may, in fact, lie at the base of national conflicts and war and other undesirable things. Is this something we should be looking at? It seems to me that this is certainly going to be on the horizon sooner or later.

Palfreman: Let's pick an easy one, which would be obesity—one of the *F*'s. You might want to genetically control that when you have a population that is so enormously fat that they don't fit into aircraft seats.

Gregory Stock: That segues into the idea of germline interventions and reshaping ourselves at a genetic level. What is surprising is that we were just talking about what is possible within 25 years, and French spoke about a 100-year life expectancy. We have multiplied that time frame by ten and it almost seems as though *less* is possible. That is astonishing to me, because 250 years is a *long* time. Look at the rate at which things are changing. It is as though we are withdrawing from these possibilities, as though we are saying, "Well, now we have to get real, because this is big stuff we are talking about."

Let's carry that thought into the idea of germline interventions. Screening for diseases: It is very clear that through genetics, we will be able to do screenings as well as improvements in terms of changing the distribution of various qualities that exist within the human population as a whole. What will we be able to do in enhancement: actually moving towards elite performance, towards super elite performance?

Coates: I would like to ask a question before we drop Burke Zimmerman's thread. Do we know, in the aging of the brain, whether different portions of it age at a different rate, for example, the cortex versus the limbic system versus cerebellum versus the medulla? If we look at age extension, would we possibly be creating some very interesting patterns of relative defects in different parts of the brain as we live longer? The basic question is: Do different parts of the brain age differently, as far as we know?

Andreadis: We do not know that different parts of the brain necessarily age differently, but what we know is that we get the most trouble from the latest addition, which is the frontal lobe. What makes us uniquely human, which is our extended frontal lobe, also is the part where dementia usually hits, plus your hippocampus, which is where your memories are. Your cerebellum, which is your movement center, is usually spared. Very few people have any problems with the mid-stem and so forth, so if you are talking about neurodegenerative diseases, your upper centers get hit preferentially.

Coates: It would be interesting if we had a degenerate upper system and a wild, full-bang cerebellum and hippocampus.

Andreadis: Then you would be a very interesting performing machine. You would probably perform very well with some things. Women's dreams.

Gregory Stock: To stimulate the discussion about germline, about genetic interventions, let me mention a paper that was in *Science* a couple of weeks ago. Anjen Chenn writes that ß-catenin causes foliation of the brain in mice. Basically, by affecting the progenitor cells, he does a knock-in in mice and he gets mouse brains that are much larger and folded like human brains, and he did that with one gene. So, there are significant possibilities of actually making major changes that, if they are done at the germline level, may result in all sorts of organizations that would be functional. Who knows?

Can you genetically engineer longevity with high cognitive function?

Palfreman: This would be the question. If we are fairly pessimistic about our ability to maintain brains longer, perhaps using germline therapy would be the key enhancement you would want. When you observe these incredibly gifted elderly people like Linus Pauling, they probably can do that because they started at a terribly high point. Their brains have been gradually declining,

but when they are 101, they are where most of us are at 50. So, of all the enhancements, maybe this is the first one we should talk about. Can you genetically engineer longevity with high cognitive function?

Coates: There is a classic work on age and achievement that is relevant here [*Age and Achievement*, American Philosophical Society: Princeton University Press, 1953]. Back in the 1950s, a researcher named Harvey C. Lehman did a study on age in relation to achievement across about 20 different categories, from mechanical engineer to Popes, from inventors and physicists to jurists. What he found, looking at the scientific community, is that creativity for first-order achievements peaked somewhere around age 35.

However, if you went to categories like historians, the peak was a decade later, because unlike scientists who can move to the leading edge quickly, before you can say anything of significance about history, you have to build a tremendous body of information. On the other hand, you could move to the leading edge of mathematics in your 20s.

Now, going to second-order achievements and to third-order achievements, which are still important enough to be noted in textbooks, the period of high performance was longer and longer. By the time you get down to third-order achievements—still textbook-noteworthy—people are productive on into their 60s.

This has to do with the point Jon is making here: It may not be that there is a steady decline as one ages. It may be that after one or two great accomplishments, for other reasons—Lehman gives 35 possible reasons—creativity falls off. It may be that instead of staying in the lab, you are made a dean. But the point Jon is making is not sustained by the information Lehman put together. It is a classic work.

Palfreman: I was basing my comments on the Digit Symbol Test. If you are testing cognitive ability—just processing rather than knowledge—it is an arbitrary test that goes down by two points after the age of 18. I remembering doing it on Ernst Mayr, who we all agree is a very clever guy, and he was way below his students on this. It tests the speed at which you can match a digit with a symbol. It is a mental-processing task. If you take knowledge out of the equation, we do decline.

If there are particular gene alleles that are associated with a slower rate of decay, we will find them. That will be fairly easy to do.

Campbell: One thing we should realize is that finally we can do definitive genetic analysis. The reason that there is so much argument about the purported genetics of complex traits like mental abilities is that until now we could not do rigorous genetics. But that has changed. If there are particular gene alleles that are associated with a slower rate of decay, we will find them. That will be fairly easy to do. I think that will be one of the least controversial things we can expect in not even 250 years.

Gregory Stock: In ten generations, John, what do you think about the engineering of human intelligence or enhancement to cognitive function?

Campbell: It depends on how you perceive that we will genetically engineer those changes during the next 250 years.

Gregory Stock: Rather than what will happen in 250 years, technologically what would be feasible, if we moved aggressively in this realm? What are we capable of doing; what is the best-case scenario?

The amount of possibility is enormous…If we change as fast as we theoretically could, we would be not a different species…we would be a whole different kingdom of organisms.

Campbell: If we really went at the greatest rate possible, we would be able to accomplish, in ten generations, far more than we have been talking about for 40 generations. The amount of possibility is enormous; I think it is essentially unlimited. The real question is: What would drive this change to be as fast as it theoretically could be? If we change as fast as we theoretically could, we would be not a different species; we wouldn't be a different genus; we would be a whole different kingdom of organisms.

Coates: It seems to me that we have evaded discussing two issues so far: Why would anyone *want* to live longer; why would the society want people to live longer? Second, what is the process by which extended longevity will be introduced?

Palfreman: That is an "influence" question.

Gregory Stock: Yes, let's hold off on that. Let's come back to that.

Jeffry Stock: If what John is saying is correct, it seems that logically we would make animals more intelligent. Are we going to get primates that are as intelligent as we are now? Those experiments will be done.

Campbell: I think we are going to be concerned much more with our own evolution than with that of other organisms. Yes, we will want seeing-eye dogs that can see better, but the real impetus, the thing that will drive people, is their own evolution, not the evolution of monkeys.

Gregory Stock: Jeff is saying that if it is possible to do that technically, one of the intermediate steps will be animal experiments. A natural outgrowth of that, although our interest is still in ourselves, will be that we are going to make incredibly bright mice; we are going to have dogs that are very smart.

Campbell: I presume that, indeed, we will use animal models for studying enhancement of intelligence, just like we have used animal models for so much other medical research. However, I still think that the rate of progress of our line is always going to far outshine what we do with other species.

Jeffry Stock: Historically that is not what has happened. All of our cohort species have evolved incredibly compared to us since we have become civilized.

Andreadis: Right.

If there are experiments occurring on animal systems, then there will be animals around that are as smart as most people…

Gregory Stock: We can speak of what is going to happen to humans, but in fact we have six billion humans, and the kinds of things we can imagine to occur in a short number of generations are going to apply to only a small number of humans who are on the leading edge. If there are experiments occurring on animal systems, then there will be animals around that are as smart as most people, and there will be some people who are really bright. This will present a very challenging realm.

Campbell: I don't have any problem with what you say. That is certainly true. I think the reason animals have fared better in the past thousand years than we have is that we have already achieved the advances that were possible from manipulating the genome without really knowing what genes are and without being able to scientifically and directly go into the genome itself.

Gregory Stock: Then there is the issue of life span. Because we are the manipulators, if we can manipulate mice, which have a three-year life span, we can obviously do a lot more with ourselves.

But, if we create a society that is also benign and altruistic…is this going to make it more susceptible to conquest by those who are not so modified…?

Zimmerman: It seems that in a 250-year period—that is a very long time, given the rate of progress and understanding of the relationship between gene and function, and even brain structure and function—we would be in a position both to enhance intelligence via the cerebral cortex as well as do emotional engineering.

The question is, then: How is this going to be done in a way that won't have corollaries that are very undesirable? You can certainly say that it is an advantage if we have a population of humans that is much smarter than we are now. But, if we create a society that is also benign and altruistic and has all these qualities that we may consider desirable, is this going to make it more susceptible to conquest by those who are not so modified and still operate on the power of selfishness?

Andreadis: On the question of emotional engineering—by whatever method, whether it is genetic or pharmacological—in fact, if you do that at the genetic level, especially if you do it on germline, you are *de facto* doing speciation at that point, because these products will not behave the same way. Now that is a definition of the mate. If primates mate, they have a certain way of seeing things, of organizing their societies. If you change that baseline, you have created a different species, *de facto*.

Gregory Stock: But species are often considered in terms of reproductive isolation. In fact, reproduction is now mediated through the laboratory, so it is no longer clear what *species* means.

Andreadis: If you engineer animals to be as intelligent as a certain stratum of humanity, the question is now: To whom are you going to give rights? We are talking again about lines. Who is *self* and who is *other*? There is a blurring of the lines there—which I think is interesting.

Gregory Stock: This leads to the question of who we are as humans and how we see ourselves. As we start doing these kinds of enhancements, because of the possibility of their application on other life forms, the lines between us and other forms of life become blurred. That becomes very challenging. It is not just about our own view of ourselves; it now becomes blurred with our view of other creatures.

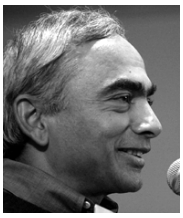
Where I want to go next is to try to look at the line between biology and nonbiology.

Coates: What I am concluding from your point is to ban what you are talking about. If you ban it, it isn't inevitable, as you are suggesting.

Gregory Stock: It depends on whether you think you *can* ban something of that sort. I think that is very hard.

…as we get away from an anthropocentric ethics…perhaps we will have responsibilities to animals as well.

Hughes: To quote Spiderman: "With power comes responsibility." One of the outcomes I mentioned in the first period was that we will have "wrongful life" suits as children are born with conditions that could have been changed or could have been foreseen, and they will be angry about not having it changed. We will also have the responsibility in the future, as we get away from an anthropocentric ethics, not only to raise the intelligence—not only from 80 to 100, but from 100 to 120, and from 120 to 140—of our children, but perhaps we will have responsibilities to animals as well. This is extremely hypothetical, but you can imagine a regime in which we looked at primates and said, "It's too bad these primates can't talk to us." Maybe we do have a responsibility, to the extent that we can, to intervene with primates and encourage them, not only to be healthy and happy, but also to be intelligent enough to have their own culture.



…what is the inherent value in humanity's going to 150 and 200 and 300 IQs?

Velamoor: If we were to step back, look at the past and come to the present, humans have remained essentially the same, in terms of brain capacity, but the quantum of what we know is orders of magnitude larger. In that sense, what is the utility of simply raising the brain capacity of individuals? I can see the value of saying: "Take everybody who is 60 and 70 and 75, and make them 100, so we can all function better," but what is the inherent value in humanity's going to 150 and 200 and 300 IQs? The capacity to know is not determined by all individuals on the planet suddenly enhancing their IQs.

Gregory Stock: Sesh just brought out an issue that is very central. The kinds of things that are of value to us are very much shaped by what is in our environment. If we have computers, to be able to do computation in our heads is relatively useless. We can do that today with a computer. A lot of forms of memory are not very interesting, because we have Palm™ Pilots and other such externals. The question is: How is the progress in technology, which we know is *so* rapid, going to shape what we would actually hope to achieve biologically?

Palfreman: If people can live longer because of the changes in medicine, they are going to want to live longer with high cognitive capacity. That could be the main driver: simply the desire of people not to degenerate at the current rate.

Second, before you go on to the nonbiology discussion, we didn't discuss whether we will have artificial chromosomes 250 years from now. Will they work ten generations from now?

Anderson: I would think so.

Gregory Stock: I would think so. That technology, I assume, could mature and begin to be feasible in 50 years. French might have more to comment on that.

Anderson: In one generation, I don't think so. But by 50 years it is reasonable, just looking at the rate of progress and assuming that it will continue. By 250 years, yes.

Gregory Stock: We will be beginning then to be capable of doing major rearrangements and adjustments of genes and their promoters, limited by the structure of the genome, the complexity of it, and what is feasible through interventions.

The problem is going to be the total regulation of the total system…

Anderson: The problem is going to be the total regulation of the total system, which is why Lee Hood is actively looking at systems biology. I forget the exact number, but if you change the level of galactose, something like 58 different enzymes change levels. We have an extraordinarily complex nervous system.

I don't think that we will, in 250 years, understand our brain. But you asked a much simpler question: Will we be able to have artificial chromosomes that can be moved into cells? Yes. Will we understand the brain and thinking and what consciousness is? I don't think we are going to know about that in 250 years. We will know a lot more, but I don't think we will fully understand it.

Gregory Stock: You can look at it this way: You have a linear sequence, essentially, of genes going into a black box that is extraordinarily complicated, and there are a lot of other inputs; then out of that comes various phenotypes. We will have some control, it seems, over some major aspects of what that genetic input is. We won't really know the complexity of the workings of that, but I suspect that there will be some relationships between genotype and phenotype that are reasonably straightforward or within the power of our design functions.

Anderson: We are not going to understand everything, but we are going to be able to accomplish more and more, and have more and more effects where the risk/benefit is appropriate, over time. In 25 years, we will be able to do a certain number of things; by 250 years, we will be able to do lots of things, but we are still not going to understand all the subtleties that are involved in a human brain and a human mind.

Gregory Stock: Agreed. For 250 years, we know the predictions that are made for artificial intelligence, for computing power. Those tend to create rather extraordinary possibilities within a matter of less than 100 years.

Andreadis: You conflated two very different things: computing capacity, yes; artificial intelligence—that is a different kettle of chips.

Gregory Stock: I was speaking in a loose way of computational levels.

Andreadis: Computational capacity, absolutely. But if you are talking about artificial intelligence, are you talking about the top-down or the bottom-up? Expert systems are very good at their predictions within that narrow sphere. It is not the same.

Gregory Stock: I am talking about computational speed and capacity, at this point. Now, how that translates into AI, into meaningful adjuncts or extensions of ourselves: That is the issue. What do you think?

Andreadis: Do you mean true artificial intelligence?

Gregory Stock: Let's talk about it in terms of the relationship with our bodies, including chip implants and aspects of our melding with nonbiology that would affect what we have agreed is the central aspect of ourselves, which is our cognitive function.

…if you extend our current brain more than about ten percent, you won't be able to integrate the impulses from one part of your brain to the other…

Andreadis: I had an interesting discussion earlier in the day. Someone said, "Why can't we extend our brain?" An example is the storage problem: The brain gets full; what do we do? One answer is to get a bigger hard drive. It turns out that if you extend our current brain more than about ten percent, you won't be able to integrate the impulses from one part of your brain to the other, because you will have exceeded the speed at which the neurons can integrate what you bring in. If you want to talk about split personalities—apparently you will have one. It is like exceeding the speed of light: Some parts of your brain will not know what other parts of your brain are doing.

If you are talking about chip implantations, it depends on what you want to do. Do you want to improve your vision? That is one thing. If you want to improve your cognitive capacity, that is another.

Gregory Stock: Let's make it simple: added memory that is immediately accessible.

Andreadis: You already have that much more simply. It is called "a computer;" it is called "a dictionary." Asimov said, "The best computer is still a book." You don't have to click your mouse; you just go from page to page. Again, you are dealing with something that can be done much more simply. You say the same thing in your

book, Greg: It is much simpler to do certain things than put chips in your brain. It's better.

Gregory Stock: That is my contention.

Velamoor: There are always people who want gadgetry, though. It doesn't matter whether it does anything or not.

Gregory Stock: So, we are talking about implants versus devices with which we are associated very intimately.

Hughes: As a comment on why people would want it—this is both an ethical consideration and a personal-motivational consideration—if it is better to be of normal intelligence than to be retarded, then why would any of us not suspect that it would be better to be a genius than to have normal intelligence? To go further: If it is better to live an extra 20 years from 50 to 70, why isn't it better to live an extra 20 years from 70 to 90? I don't understand this questioning of why people would want this. It is understandable both in personal motivation that we will all want to be smarter and live longer, as long as we are healthy and have the capacity to enjoy our lives, and it is our ethical responsibility to ensure that for our progeny.

Now, in terms of Ray Kurzweil's scenario, I find compelling the notion that there will be, within this century, nanotechnology adequate to the task of establishing within the brain a latticework that communicates with the brain at a very deep and very pervasive level. It will allow for a communication between the brain and computing media of various sorts, and that will allow us to model brain processes at a very deep and intimate level—and eventually, perhaps, upload or copy parts of the personality into other media. I think that is a compelling scenario.

Zimmerman: Are there any clues about how this interface would work?

Jeffry Stock: The Defense Department is working on this. There is an array of probes that go right into the brain. It doesn't seem to work very well. It is refreshingly crude. My impression is that you have a sensory input and a factor output. Nobody has succeeded in doing anything original, such as directing a device. There was a *Nature* article on it recently. You teach the monkey how to do a particular task, and with the electrodes you have in its brain, you get a certain set of signals corresponding to that task. Then you can have the monkey do the task again, and you can pick up that output and run a driver to do the task.

Hughes: It is being done today.

Our brains aren't designed primarily only to communicate with other individuals or machines; they are designed to run our bodies…

Jeffry Stock: Yes, that is being done, but that is different from what people want to do, which is have the implant and then be able to learn to drive the tank with your brain. Yes, you could do it. Our brains aren't designed primarily only to communicate with other individuals or machines; they are designed to run our bodies and do the incredible things our bodies are able to do. As that becomes less important to us, there is a tremendous capacity there that may be accessible, when we understand it, to do other things.

Coates: Triggering off individual activities or interfering with individual activities is now well established. You can get into the brain with a microprobe and affect Parkinson's tremors. You can induce movements. In fact, 15 years ago it was a party stunt to operate your electric trains with alpha waves. That is all relatively uninteresting. The thing Kurzweil is talking about, which I think borders on science fiction, is dealing with what are fundamentally the higher cognitive functions and memory. As I pointed out before, we simply do not know how an event is dismantled into memory, and we have no notion of how those dismantled pieces are pulled together again into a recollection. Until we have an adequate explanation of that, this notion of putting in some kind of memory probe just simply is at the level of science fiction. There isn't even a clue as to how memory disassembles or assembles images and hence how you would intervene in it.

My point about looking at that kitchen: Right now, neurologists do not know how that image is broken down into components and stored. Tomorrow, if I think about it, they still don't know how that is reassembled in my brain. Therefore, it is impossible to conjecture reliably what a computer-assisted device or a chip would be like that could integrate with that system. Are any of the neuroscientists in the room ready to say that I am wrong on this?

Jeffry Stock: I will say that you are wrong.

Coates: You're a biochemist.

Gregory Stock: In terms of influences, what are the kinds of things that will shape the paths of development of these possibilities? Does anyone have thoughts about that?

Fowler: Listening to all of this, I am wondering: Are we making the assumption that 250 years down the road, everyone is the same, that everyone has these capabilities?

Campbell: No.

…what roads will we be actually pursuing if indeed we have the same kinds of structural problems that we are experiencing now?

Fowler: So, there are the same sorts of access issues and the same questions of "what does the medical practitioner do in these situations?" I am thinking of what French was saying and what was so touching about the question: How do you deal with people who are not yet at these particular points? Where are they on the spectrum? What are the issues of autonomy, for example, in how we treat our own bodies? What relationship does that have to the accessibility that others have? Do we do harm to others? Are we driving these particular technological advances by everybody wanting the same thing? It seems to me that we are dealing with issues right from the beginning about what we are *capable* of doing, but what roads will we be actually pursuing if indeed we have the same kinds of structural problems that we are experiencing now?

Gregory Stock: Here we come to the question of what the level of influence is and what the competitive mechanisms, the evolutionary mechanisms are. Obviously if these technologies are useful in some way—it is not clear the extent to which we feel that they will be, but if they are, and they give us an advantage—then those who embrace them are likely to be more successful in some way. There are some evolutionary implications for that.

The important thing is: What advances the capacity to evolve?

Campbell: You have to look at the things that are happening to humanity or society as a process of evolution. Then, if you ask the question: What is the use of it? Why would people do that? I think you have to ask that in the context: What utility does it have for evolution? The people who are going to advance the most are the people who are wedded to the idea that this is an evolutionary process and that they want to advance in terms of an evolutionary process.

The important thing is: What advances the capacity to evolve? And that has positive feedback. If you advance your capacity to evolve, then you will be able to evolve more capacity to evolve. If you focus on some other trait, such as musical ability, you may be able to make steady progress over the generations, but not exponential progress. Traits with this feedback that the more they progress the faster they can progress in the future will become increasingly prominent. Those that do not boost their further rate of development will be relatively less important.

Velamoor: How will that process be moderated or affected by the opposite impulse you also see, which is the utilitarian one of "the greatest good of the greatest number"?

Campbell: The crucial thing is not to think that humanity is going to be evolving as a unit. Individual groups are going to explore every possibility there is for germline engineering and non-genetic enhancement, and there will be a huge amount of variation. We will see what wins out. I think most things won't win out.

Velamoor: I agree with you, in spite of the under-utilitarian impulses.

Gregory Stock: And you will get self-reinforcing, tight feedback groups. As Joe mentioned, there is the possibility for diverse groups to get together through the communication infrastructure we have today, so it doesn't matter what society as a whole decides to do or "what's the greatest good," if there are small clusters, no matter how they are scattered, that can draw upon this knowledge and use it in ways that reinforce themselves. Then where does it lead?

Palfreman: One possible negative feedback could be this issue we were discussing about longevity. A society that invests in keeping people alive might find itself with a brake on how dynamic and able to adapt it is—right?

Campbell: That's right, but if you look at evolution, there are many, many failures for every success, and a self-negating trait (one that denies its further evolution) is not going to be important in the future. What we should try to identify are the factors—cultural, technological, and so on—that will have positive feedback for increasing themselves over time.

Gregory Stock: Why do you think we should identify those, considering that your view is that we will be trying out this whole space and whatever works will work?

Kirk Citron: And could you be more specific? I am having a hard time seeing what the visuals are, what the actual range of possibilities is. If we are going to be trying all these different things, can you describe what the different possibilities are, what they look like?

Campbell: There is an enormous potential range: beauty, athletic ability, docility, cheerfulness, health, intelligence, and so forth. I think that the most successful group at becoming the most influential, significant, and advanced in the future will be one that explicitly dedicates itself to this goal. These descendants will have to use their next-generation technologies to enhance themselves so that they can enhance themselves in the future. Of course they will have to successfully instill this vision into the next, and succeeding, generations. Also, progressing at the maximum rate possible—that will be their only goal and the only thing that matters to them—not what else "should" be done or the rest of society. I think there will be hundreds of different groups that will have different sorts of programs, and the question is: Who is going to win out?

Gregory Stock: Let's take examples and possible environments for that. One is the example Jon came up with of the deaf culture, where we believe that deafness is not a disability, but is very important for our culture. I could see that as a self-reinforcing cultural norm. Another example is a group called the Extropians, who would like to see any type of enhancement accelerated so that it occurs as effectively as possible. There are various splinter transhumanist groups who would embrace this kind of change for the sake of the change. They have a very high tolerance for risk in this pursuit. Where does this occur? It could occur on this planet. We could also imagine it occurring out in space, where you begin to get separation.

Andreadis: Let me give you an example where deafness *is* an advantage: outer space. There is no sound. No sound is transmitted. All those booms you hear in science fiction movies are just for the benefit of the moviegoer. That means that the most efficient thing is to know sign language. If you are going to be outside repairing the space station, you have to know sign language, and it might be an advantage if you already know sign language.

Gregory Stock: Or have telecommunication of some sort.

…we have to come to grips with the idea that we are not the pinnacle; we are actually the foundations of the next group of species.

Andreadis: But there are times when your technology fails, and then you have to have a backup. If you have a biological backup, that is more robust than a technological one, often.

An added point, which we have been skirting and have not said in so many words, is that for us to go into the next stage of the 40 generations and see this change continue the way John has said, at an accelerated evolutionary pace, we have to come to grips with the idea that we are not the pinnacle; we are actually the foundations of the next group of species. And it is going to be a *group* of species. We will have radiated into groups.

Moran: That is an interesting point. This is something that comes up with dogs. What I am imagining is subsets of people evolving in different ways to end up like bulldogs and poodles, but they are all still one species. In 250 years are people just starting to evolve into different subgroups but they are still one species?

Andreadis: The definition of a species is that you can have children, so you can actually see a species arising by mistake by a really significant mutation. That is one possibility. The other possibility in this case, because we are cultural animals, is that we will make isolated breeding pools by the fact that some people are not going to like how the others look, and that is your *de facto* definition of starting to diverge. Dogs still like dogs regardless of whether they look like poodles or what, and you breed back to the wolf shape. Humans are different in this regard.

Hughes: One of the positive feedback loops and amplifications we have been ignoring—and it is one of the reasons I see this conversation as rather conservative—is intelligence amplification, both within the organic brain and the increasing sophistication. Even if we don't have artificial intelligence, even if we have just incredibly powerful computers of whatever sort, all of these technologies will be increasing the productivity and the accelerating rate of change of scientific knowledge and scientific innovation and the reach of science. A lot of this discussion has been rather linear in its projection of what scientific capabilities are going to be. We have to be thinking exponentially.

…if we have…subsets of humanity, who engage in enhancement activities…that make them different from the mass of humanity, where does that lead us?

Gregory Stock: Another aspect that emerges from this is the notion that if we have small groups, subsets of humanity, who engage in enhancement activities and who will have access to advanced technologies that make them different from the mass of humanity, where does that lead us? We end up with huge disparities in these scenarios, however we project the possibilities. Even if you have medicine reaching everyone, it is at a slower rate, and just the changes in rate make for greater differentials. That creates incredible conflicts.

It is hard for me to imagine scenarios by which those conflicts associated with the initial stages of speciation, of alteration, of adjustment, don't occur. Everybody tries to ignore them by saying, "Well, we will all make decisions about the greater good," but I suspect, from what I am hearing here, that that is not going to be possible in these technologies. It is going to be used somewhere, and there will be differences arising.

Palfreman: What you are talking about—I must say that I find it a bit farfetched—sounds like a spontaneous resurgence of eugenics, essentially, where you will get these cults who want enhancement.

Andreadis: Not eugenics; divergence.

Palfreman: But they want to get better. We have so many social forces against that kind of tendency.

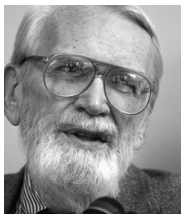
Gregory Stock: But the aspect of eugenics I think you are referring to was an effort to alter the human population as a whole, to improve humanity. This is completely different because these are groups that do not care about humanity; they care about themselves; it is personal enhancement. Everybody is engaged in that at some level or another: They are trying to give opportunities to their children; they are trying to get access to better technologies.

Andreadis: They are trying to build up their muscles.

Gregory Stock: Yes. That is what we are talking about here. So, the question is: Is this the thing that is likely to occur?

Coates: We have the experience of the world today. If you meet one of those people in Africa or Asia who is earning 50 dollars a year, are they necessarily ready to go to war with you because you are earning several orders of magnitude more? Differences themselves do not necessarily imply aggressive hostility; you have to look at the context that would foment that kind of hostility, and you haven't come up with any of that.

Gregory Stock: I am not saying that there necessarily has to be conflict. I am saying that there will be increasing amounts of difference, and I don't know how those will be manifested.



What kind of parent is going to subject a child virtually from birth to a drastic, uncertain, open-ended experiment?

Coates: Okay. But coming back to how this is going to be initiated in this relatively brief period of ten generations, take the longevity situation. My assumption is that if we are going to have significant increase in longevity, a shift in the set point, we are going to have to begin virtually at birth. That means we will need to have a lot of evidence—done on other primates: chimps, gorillas, orangutans, and so on—that somehow this does add to longevity without being disruptive. How long will it take to do that?

Let's say a chimp lives for 30 years. It will take about 60 years to establish in fact a substantial increase in longevity, and to establish what it really is might require 90 years. Therefore, you run up against the question: What kind of parent is going to subject a child virtually from birth to a drastic, uncertain, open-ended experiment? I think it will have to start very, very small. And if it starts very, very small, it will have very limited social consequences. The question then is: At what stage would that small number of experiments lead to enough exponential growth that it would become a significant factor in the society?

The other side of that, not talking about children now but adults: All the evidence I see suggests that it would be hopeless to substantially increase the life expectancy of anybody in this room by any significant amount. The rot is already under way. You are already halfway to your tomb. The notion of extending your life three or four or five years—sure; wipe out all the diseases and you have five years more to go. The question of interest has nothing to do with adults; it has to do with children. And how are you going to initiate the process on a scale large enough in a mere 250 years to make it the significant thing that you seem to think it is?

Jeffry Stock: I completely disagree. What is going to be enhanced with genetic profiling is preventive medicine. For instance, pregnant women don't drink: This is a new thing. What is going to be the effect of that? We also have all kinds of nutritional supplements.

Coates: No effect on the set point. There is absolutely no evidence that any improvement in human behavior—exercise, diet, nutrition—will have any effect on the biological set point.

Jeffry Stock: I will give you an analogy. If you drive your car and don't change the oil, the set point on that car is going to be relatively short compared to if you drive your car and change the oil all the time.

Coates: I drive 5,000 miles a year and my car is as rotten as if I drove 12,000.

Andreadis: The answer is enhancement. For example, nutrition has changed the age of menarche.

Coates: It hasn't changed the set point.

Andreadis: Yes, it has. It has changed the set point at which a woman can reproduce.

Coates: It hasn't changed the set point for death.

Andreadis: If it were not for the cultural compulsions, you see that ghetto children have reverted to teenage pregnancies.

Coates: If that is what you want to talk about, it is accelerated birth. In Norway in 1790, the age of menarche was over 17; in New York City today the age of menarche is about 12. There has been a five-year drop in 200 years. But that has nothing to do with the biological set point. They are still going to die as a member of this species at age 85 to 90, plus or minus.

Gregory Stock: Your statement that there is a set point is dogma. There has been continual increase in life expectancy for the oldest of the old. That has continued to go up. And it is not at all clear that new knowledge about the understanding of aging will not have impacts.

Coates: My point is that it is not clear enough for you to make radical judgments.

Gregory Stock: You made a statement that all of us are rotting already. For a while, we ripe and ripe, and then we rot and rot. But then you made a jump to say, "Therefore, this doesn't work with adults, and it can't have impacts in short periods of time." That is you. Somebody who is ten years old, or 15 years old, or 30 years old may well have interventions that arise before they have begun to rot substantially.

Coates: But when you are talking about juniors, it has to be an adult decision. What kind of adult is going to subject children to a major, uncertain, biological experiment with uncertain, mixed outcomes?

We are talking about the technical potential to intervene—if that exists, there is not the least doubt in my mind that there will be enormous utilization of it.

Gregory Stock: People are willing to subject them*selves*, at very early ages, to experiments that would be likely to gain some slight amount of increased *appearance* of youthfulness and are almost certain to have negative physiological consequences. We are talking about the technical potential to intervene—if that exists, there is not the least doubt in my mind that there will be *enormous* utilization of it.

Coates: Let's take that as the model and let's say, as a specific example, that two percent of the users of drugs become drug addicts. That is a nice model for what you are talking about: "I'll do anything to remain beautiful; I'll do anything to remain healthy; I'll do anything to have a good time." So, they try drugs and two percent become addicted. The phenomenon is extremely limited in this society, and over this 250-year period, are we going to reach the numbers that make it a socially interesting cohort?

Hughes: We're talking about glasses; we're not talking about drug addiction.

Coates: I'm using it as a model of the willingness to do things in the extreme for your own personal aggrandizement: "I want to have a great time; I'll try drugs." Of those who take drugs, two percent become addicted. That is, they have a permanent, irrevocable commitment to it. It is a very small percentage of the population.

Velamoor: Perhaps we can settle on this: Since there is quite a time difference between ten generations and 40 generations, we can extend this period from ten generations to 15 or to 20 and create a range. Ultimately, the process could start with the tenth generation and continue to the twentieth.

Gregory Stock: As I said earlier, 250 years is a very, very long period of time. If we are not talking about changing all of society, which has an enormous inertia, then I think we are being very conservative about the possibilities that exist in the future. Benjamin Franklin looked forward and commented that he had been born a thou-

sand years too early because the power of science over matter was limitless. Look what has happened in that short period of time. If you look back and see how far we have come, and now look at the rate at which we are moving—think of the possibilities! I am not talking about moving society as a whole, but think about the possibilities that exist with the unraveling of human biology that is occurring today. I think we are being extremely conservative.

Velamoor: Would the pattern be any different from what Kirk was raising a little while ago? Today, for example, I don't think 40 percent of the population on the planet has or can afford a bicycle. Virtually every child in the United States has one.

Gregory Stock: If we are talking about small groups of people as the model here, then we can accelerate the rate at which changes occur. Usually the discussion is about all of society: How is society going to be changed by germline engineering, *in vitro* fertilization, various kinds of enhancement? Well, we don't even have enough food! A small group impacted by these changes might be one percent of the population. One percent of the population is a lot of people. If these changes are of substantive value—which they are not yet, other than in areas of health—either in longevity or in human performance, they will have huge impacts on our future. It doesn't take many people.

Campbell: Look at our revolution in understanding achieved in just the past several hundred years. For example, we discovered that the universe operates mechanistically. It used to be thought that God runs the universe; then we discovered that it is mechanistic. We have learned the secret of life. If you had asked people 500 years ago what life is, they would have had no idea. They would have said that was an insoluble problem. We also have solved the problems of genetics and our development, and those used to be explained by special theological mechanisms. So, it strikes me that what we really have to concern ourselves with are the big issues. There are some "biggies" that still boggle us, because our minds are not big enough to grasp them.

One of them is mentality. What *is* a mental image? What *are* sensations? We have no idea. Time is a concept with which we really struggle. It doesn't make sense to us, but that doesn't mean that we couldn't evolve the intellectual capability to understand it. Causality is another. These are biggies, and the only way we are going to master them is by increasing our intellectual capacity so that we can understand them.

…the genetic revolution is going to reveal the fundamental processes of human thought, and I think that will happen over the next hundred years.

Jeffry Stock: This is on the problem of neurobiology and how fast we are going to understand neurobiology. In my experience as a working biochemist, we are going to understand neurobiology a lot faster than we think we are. We understand metabolism because it is a physical interconversion of different chemicals, which we have been able to work out using the techniques of chemistry. The problem with regulation and sensory-motor control and brain function is that there is no tangible thing but a bunch of electrical impulses and local phenomena that we can take apart and look at.

In working with microorganisms—we are beginning to really pull that apart; that is the first organism where we do understand, or are beginning to understand, how they regulate their behavior. The key was genetics. With genetics, when you get the genetic profiles and really start to look at different people, you can begin to see what components are important and how the whole thing works. So, we will be able to get the information in the black box. With most cells and most lower organisms, it is starting to be genetics, so the genetic revolution is going to reveal the fundamental processes of human thought, and I think that will happen over the next hundred years. I think it is not as difficult a problem; it is an ephemeral problem because: What is a thought? It is difficult to grasp.

Andreadis: Regarding the suggestion that a very small percent of people is not relevant to society or life's numbers: If you consider this an evolutionary process, if you get a group that is more successful, in fact it will take over that niche. The fact that you started with a small group does not necessarily mean it is always going to be peripheral. Size and effect are not causally connected.

The second point is about neurobiology and about the "biggies" and the "smallies." It is unlikely that Newton and Einstein had much different brain capacity, in terms of volume, in terms of folding, in terms of numbers of neurons. What makes those sudden jumps in knowledge, I think, are paradigm shifts. You don't necessarily have to have more brains, but if you start thinking a different way—You say, "the brain is a clock." "No, the brain is a computer." "The brain is a hologram"—these are different ways of thinking about it. Some of these are better than others. But when you make that

shift, you see the whole thing in a different way. This is the so-called "click," the hunch that scientists sometimes have, after they have accumulated enough to see the pattern.

Campbell: I don't think there is any way you can "shift the paradigm" so that a chimpanzee can understand quantum mechanics. There are some things our current minds are simply incapable of understanding; it is not a matter of just paradigm shift. I think we are going to have to advance as much above where we are now as we have above the chimpanzees. That's what the real prospect is.

Palfreman: With a subgroup, how do you measure success? It doesn't mean that the elite group will want to breed. The population of Italy, for example, is practically going extinct.

Genes or clusters of genes can be propagated not just through sexual reproduction but via the laboratory. They can be spread in that way.

Gregory Stock: That pulls us into what I wanted to say as our final comment: If you look at this as a competitive function—look at what happens with machines. When you have a technological breakthrough, it very rapidly diffuses into the population as a whole. So, if we move beyond the point where human reproduction is caught up with sexual activity and where lineages are very simple, then it is possible that advances—be they germline advances; something that is of significant value—can spread through the population rather quickly, almost like a virus. That is a very different model. It opens up possibilities for rather rapid changes that are manifested broadly. Genes or clusters of genes can be propagated not just through sexual reproduction but via the laboratory. They can be spread in that way.

Success is going to be measured in the same way it has been in the past, by the same way it is measured in memes: by the rate of propagation, the same way it is measured genetically. But the mechanism of propagation and reproduction may well change as we move into the future, especially as we get to 250 years.

Hughes: I am an old-school world Federalist. I am much more optimistic about the obsolescence of the nation-state and the rise of global governance, and the concurrent rise of a global ethic of egalitarianism than apparently some are.

As a consequence, I think that not only will there be the spread through competition or copying of obvious advantages that other groups have, but there will be an ethic. Just as there is within the European Union now, where Sweden and Germany have a responsibility to share technological benefits with Portugal and Greece, there will be a responsibility that the North will have to support the diffusion of beneficial genetic therapies to the Third World. We already have that responsibility. I think it is going to get stronger, and by the time 250 years roll around, I will be very surprised if there is anything resembling the nation-state as it is today.

Gregory Stock: Do you think that would reduce the differential? It seems to me that if you have the pace of change accelerating, you still have an increase overall but a continued expansion of the differential.

Hughes: I think there will be unevenness, but I don't think we can predict the direction it will go. For instance, a country like Singapore might leap ahead with some of its policies, just as with telecommunications. Some Third World countries invest in telecommunications infrastructures that are more advanced than the First World has because they can't build the landlines that we have. There are some advantages that Third World countries will have that we don't.

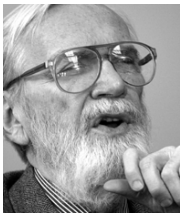
Velamoor: On that note, let's conclude this session. Thank you.

Major Issues Session III

Forty Generations (One Thousand Years)

Who will "humans" be a thousand years from now? This was the key issue facing the workshop participants in the third major discussion session.

Discussion Leader: Joseph Coates



…jot down on a sheet of paper the two most significant differences in humanity…between now and the year 3000.

Coates: I want to do this differently from the way the previous two sessions went. What I would like you to do is to work quietly, individually, not talking to each other, for just five minutes. What I want you to do is jot down on a sheet of paper the two most significant differences in humanity, whatever that may mean to you, between now and the year 3000.

This is how I would like to work the session, at least to get us started: I will ask one of you to give one of your items, and then if anyone else has the same or a closely related concept, pick that up and add it to the discussion. Then we will go on to someone else for another item, and so on. That will give us a little coherence on the ideas as they come up. When we have exhausted everything you have, then we can go back to a more open discussion. French, will you start?

…physically/mentally we will be bigger, smarter, healthier, longer living, etc.; emotionally/spiritually we will be unchanged.

Anderson: By the year 3000, physically/mentally we will be bigger, smarter, healthier, longer living, etc.; emotionally/spiritually we will be unchanged.

Coates: Does anybody have a related item? All right, let's move along.

Hughes: The majority of consciousness in an expanding sphere of 400 to 500 light-years around the solar system will be based on nonbiological platforms, probably some kind of molecular-based computing.

Coates: How is that affecting humanity?

The majority of our descendants, the majority of the continuity of consciousness that comes from us, will be based on nonbiological platforms…

Hughes: That *is* humanity. The majority of our descendants, the majority of the continuity of consciousness that comes from us, will be based on nonbiological platforms—no longer be in human bodies.

Coates: I am being innocently dense. I don't know what that means. Would you describe my life and how it would be different in this system?

Hughes: For instance, if you were one of the crew that might be sent to Alpha Centauri to colonize that planet, you might be coded in a ball of matter, very small, and all of your subjective experience would occur within that ball of matter.

Coates: I am Joe Coates; I live in metropolitan Washington. Tell me: What does this mean for me?

Hughes: What does it mean today?

Coates: No, what does it mean in the year 3000, if I am an ordinary citizen, in an ordinary place, among the x-billion of us?

Hughes: Well, that was my second point: There won't be any ordinary citizens in ordinary places in the year 3000. The idea of individual identity will be ameliorated at that point. I think we will be sharing our thoughts, our feelings, our dreams, and our identities across platforms, across bodies.

Palfreman: We'll be like the Borg?

Hughes: The Borg is a negative ….

Anderson: The Borg got a bad rap.

Coates: That's a nifty idea. Does anyone else have something related to that?

…we will have very much lower population size with small, highly interconnected groups with coordinated functions.

Jeffry Stock: Yes. I wrote that we will have very much lower population size with small, highly interconnected groups with coordinated functions. So, the people who go into space won't be the same people who are living in Washington, DC; there will be little groups of highly interconnected ….

Coates: How little?

Jeffry Stock: Maybe ten or 20 … small units of interacting people that are very highly coordinated in their activities.

Coates: The average person in this room has 2,000 to 3,000 people on his Rolodex. Now, how does that relate to what you are saying?

Jeffry Stock: I am saying that won't be the case.

Coates: We know 2,000 to 3,000 people.

Jeffry Stock: *Now* you do, but we are talking about a thousand years from now.

Coates: Why am I going to dismiss 2,980 of them?

Jeffry Stock: Because it would be richer and more functional if we know just 20 people whom we are very, very close to, and it is dangerous and not productive for each individual to have contacts with thousands.

Coates: Neat concept, entirely different from anything we have heard before. Does anyone have a related idea to develop? Burke, how about you?

Zimmerman: One I would posit is: If we are going to be here in a thousand years (and this is also predicated on the assumption that the social infrastructure that permits research and technology will survive without major calamity), we will realize the necessity, in order to preserve global integrity, that we have to limit population. And a corollary of that is that we will need some sort of effective global governance.

Coates: Okay. Anyone with a related idea?

Fowler: Yes. I think humans will see the world as common ground and all people will share a common destiny, and that we will insist on having full parity with the powerful to make policy decisions.

Coates: Why will we have that?

Fowler: This is a quality that humans will have. They will have been through the other processes—the revolution when they realize that if they are going to act like Dolly, they will end up like Dolly—so they will insist on fighting aggressively for, and seeing the value of, interdependence as much as they fought for independence.

Palfreman: So, evolution ends, for all practical purposes.

We have the choice either to get our act together and create some kind of effective global governance, or perish.

Zimmerman: Just to expand, I think the alternative is to continue towards chaos and rampant exploitation of resources, loss of species, making the planet less and less hospitable. We have the choice either to get our act together and create some kind of effective global governance, or perish.

Coates: Could we count what you are saying as an inevitability?

Zimmerman: Yes. I would say so. I would guess that we have less than a thousand years to make that choice.

Coates: Greg, give us one of yours.

Gregory Stock: I think that our life span or our cognitive existence, in whatever form it takes, will be much longer than it is now.

Coates: Give us a number.

Gregory Stock: I would say at least three times what it is now.

Coates: Two hundred fifty years?

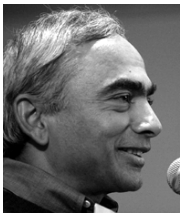
Zimmerman: Do you mean all the people on the planet?

Gregory Stock: No. I don't know a figure. I would say "very substantially" larger and not for everybody, but for the leading edge of what we would call human existence.

Coates: How many people do you think there will be? Current forecasts suggest a level-out in 2050 of around ten billion.

Gregory Stock: On this planet, there will probably be substantially fewer: maybe five billion, four billion.

Coates: A 50 percent reduction, roughly, compared to 2050. All right. Anyone else have a related notion?



…a thousand years from now we will revert to a highly structured, highly hierarchic, top-down management of the human species.

Velamoor: I think that a thousand years from now we will revert to a highly structured, highly hierarchic, top-down management of the human species. And there will be several kinds of us.

Andreadis: I see two different currents. They are antithetical to each other, but they might be able to coexist. We have touched upon them. One is collective responsibility: We all have a shared destiny, or it would be desirable if we did. That goes together with blurring of what lines are drawn as to what it means to be human. One of the things I would see in a thousand years is hybridization, for example, with silicon; possibly hybridization with animals.

The second item, which is important because we have become essentially a monoculture, and monocultures are susceptible to all kinds of woes, is the question of diversity. I think there will be speciation of some sort, whether the speciation happens because some of us leave and some of us stay, or there is a small differentiation into some elite groups. They can be as elite as aliens. We are not talking about power; power is a different thing from differentiation. There might be these groups who will have decided to reintroduce the diversity into the game.

Palfreman: We have some interesting differences here. On the one hand, we have the end of evolution and world governance. I am much more with Athena. This is quite in conflict with our 250-year scenario where we had all these subgroups developing the capacity to evolve. Somehow that has disappeared by now. I remember when the city of Brasilia was built in Brazil. They made every region of the town identical. They wanted to make it completely egalitarian. In ten to 20 years, even though all the houses were built exactly the same, you had regions that were the desirable places to live and the less desirable. It is just in the nature of humanity to want diversity and to compare and to measure ourselves against each other.

I think that by a thousand years from now, we will have intelligent machines: some kind of silicon-based entity, maybe independent, which will be a companion.

Coates: Describe an intelligent machine.

We will have given up on the idea of trying to reinvent ourselves in silicon.

Palfreman: We will have given up on the idea of trying to reinvent ourselves in silicon. Just as a common sense issue, there are incredibly problematic issues. Since machines don't have the same drives to feed themselves, have sex, and so on, why would a machine simulate a human animal? On the other hand, a machine could be independent in the sense that it could have a function and move around. It would be like our machines now, but much more sophisticated—like a very smart vacuum cleaner. Maybe a butler, or something like that. It wouldn't be equal; it wouldn't do everything, but it would do some things really well.

Coates: So, you don't see machines that somehow look and behave like people.

Palfreman: No. They are not exactly like people, but they would pass any reasonable test of intelligence. Say you have a robot butler: It will do a set of tasks that today we would regard as remarkable.

Coates: Tell me about one of these intelligent machines outdoors.

Palfreman: Maybe a car that will park itself—machines that by today's standards would pass as smart, but maybe in the year 3000 we will regard them as vacuum cleaners.

Velamoor: If there is still a soccer game, there might be a professional league of soccer for them.

Jeffry Stock: If we can have an ideal future, why wouldn't it be like Eden? Why wouldn't we be naked in a warm place with a small group of people with whom we are very harmonious?

Andreadis: That would be very boring.

…that intelligence, which will be greater than our intelligence today, will be infused into objects in the environment. It won't be independent like machines…

Gregory Stock: I think that intelligence, which will be greater than our intelligence today, will be infused into objects in the environment. It won't be independent like machines; we will actually be interacting with things we consider to be inanimate around us. We will embed cognition and consciousness in the world around us.

Coates: What does it mean when intelligence is ubiquitous? What will be different from today?

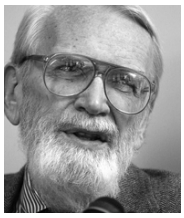
Gregory Stock: Children could interact with toys that would be able to speak to them, joke with them. We would have doors and houses that have intelligence embedded in them.

Coates: That is *Popular Science* today. *Popular Science* has articles about that. What is dramatically different in the year 3000 about intelligence?

Gregory Stock: You would interact with intelligence that is more sophisticated than *your* intelligence. You would be talking to a pencil or whatever—something inanimate and not materialized in the form of a machine.

Coates: Notice the big thing that Greg said: "more intelligent than you are." That is an extremely interesting point, and I think we have to come back to play with that. What would it mean if machines were more intelligent than we were?

Gregory Stock: By "more intelligent," I mean that it would have a richer perception of many things than you do—much like an interaction now with someone who is more intelligent than you are. It would be able to organize; it would have a sense of humor; it would be able to draw in a very rich-contextual way. For example, what is the nature of your interaction with someone who has an IQ of 70? What does that mean?



But superman is a concept that is only man enhanced…What would be special about this that would go beyond mimicking human capabilities?

Coates: That's interesting. What Greg is really describing, as I see it, is man and superman. But superman is a concept that is only man enhanced. What would be fundamentally different about this, other than having a physical neighbor that was as smart as or smarter than you are? What would be special about this that would go beyond mimicking human capabilities? Let's come back to that. Does anyone else have a comment about intelligence?

There will be the development of self-willed, self-reproducing, nonorganic life, which will have many advantages over organic life…

Hughes: This is one of the key developments, well before a thousand years, in my mind. We are going to face competition with these nonorganic life forms. There will be the development of self-willed, self-reproducing, nonorganic life, which will have many advantages over organic life, in terms of how fast it evolves, how fast it learns, its flexibility. We will have to develop policies. It may be one of the motivations for why we need global governance: to make sure that we can prevent the apocalyptic consequences of those kinds of developments.

Zimmerman: One way to look at this is: If by whatever means we create a more intelligent being, which will in turn be more creative, this is a continuous stochastic process. We cannot even imagine the degree to which the end product in a thousand years will be more intelligent than we are, and probably in ways that are not simply more of what we have now, but in qualitatively new ways that we can't imagine.

Coates: Can you push against that limitation and suggest something that would go beyond us? We recognize that your point is probably fully valid, but push to the wall: What would you see actually peeking over that wall that is better or different from what we can do?

Zimmerman: Conceptualization in ways that are very difficult, if not impossible, for everyone except a once-in-a-hundred-years genius, but that will become more and more commonplace. This would allow much faster understanding of the problems of nature, life, the cosmos—problems that we are just beginning to understand—and maybe other qualities like telepathic communication, utilizing, of course, real physical phenomena that we haven't yet elucidated. There are a lot of things one could imagine that are not simply science fiction, and probably a lot of things we cannot imagine.

Gregory Stock: Your question of what would be the differences from what we see now is interesting. Many of the things we ascribe to ourselves are, in fact, cultural knowledge that has grown out of the activity of large numbers of people and other computational devices. Our awareness of things like global warming, our ability to design machines, and so on: All of these things are actually collective. In a sense, it would just be an amplification of those sorts of potentials, and easier access to them, rather than a difference in kind. Although you can imagine what greater intelligence would feel like, or what it might be, it feels to me that it is not that different.

Coates: That's a fascinating point. Let's go on to another item from someone's list.

…more people will make the choice of when or if they will die. That will profoundly change the way people think about death.

Moran: I am not sure this would be true for all humanity, but at least for a small and growing group, more people will make the choice of when *or if* they will die. That will profoundly change the way people think about death.

Coates: Can you develop the *if* a bit? The *when* is understandable; what about the *if*?

Moran: My sense is that technology will come to a point where a person will be able to perpetually preserve himself, or what he thinks of as himself, once his body collapses.

Zimmerman: Your consciousness or sense of self?

Moran: Yes, in some sense, your consciousness. Some people will choose to do that and remain basically immortal, and others will not.

Palfreman: That is the Kurzweil idea that in the 250-year discussion we pooh-poohed; now in the thousand-year scenario, it sounds about right.

Coates: Anyone else on that point? Okay. John, what is on your list?

The most important continuous trend in the biological world since the beginning of life has been that the capacity to evolve has improved continually.

Campbell: The most important continuous trend in the biological world since the beginning of life has been that the capacity to evolve has improved continually. I suspect that is going to be the one thing that you can predict for the future: The capacity to evolve will be much greater than it is now. That gets into intelligence a little bit, because it is going to require enormous intelligence. It is also going to depend on increased commitment to the future and to our responsibility to evolve, instead of just to exist.

Most of what used to be handled by evolution seems to now be handled by cultural invention…

Kirk Citron: I would like to challenge that, because I think one thing about humankind is that we *haven't* evolved very much. There is not very much going on: Wisdom teeth are going away, so small things are evolving. Most of what used to be handled by evolution seems to now be handled by cultural invention: the invention of buildings and all the other aspects of culture. What's interesting about Greg's comments is that we may actually be going into a period in which humankind is going to start evolving again, or speciating in a way that probably hasn't happened for some long period of time. And we are going to be directing that or affecting that ourselves.

Coates: Athena had some interesting ideas on that. Would you recap your point of view *apropos* of this evolution?

Andreadis: I agree that when cultural evolution took over from biological, we actually seem to have stopped it, or homogenized ourselves. There has been a factor of ten each time. The genus *Homo* was about 500,000 years ago. Then suddenly at 50,000 years ago, something big happened and Cro-Magnon emerged. But at some point there were five or six different branches concurrently, and now there is only one: *Homo sapiens sapiens*. We figured out that we were one species, and we have been enthusiastically celebrating it ever since.

We have a single species now, but every single species has a finite lifetime. After that, you either radiate or you become extinct. It doesn't matter whether you are a human or a butterfly; that is the way it is. Now, that is not going to happen in a thousand years, because that kind of evolutionary length is longer than that. If we are going to accelerate our evolution, we will probably go back into branches.

Coates: You made a point earlier, if I understood you, that new factors are creating evolutionary opportunities different from geographic isolation, which was the basis of traditional evolution. You were talking about relationship of people, the characteristics of trends generationally, trans-species genes, and so on. Have you abandoned that idea? Tell us about that.

Once you have these groups that are significantly different, they will become self-enclosed founder populations.

Andreadis: The gist of what I said is that the point when we have interventions, whether at the level of germline or where, it obviously is going to happen by different groups at different speeds. Once that happens, you will *de facto* have separation. Some of it will eventually go back to the old business of who is attracted to whom. Once you have these groups that are significantly different, they will become self-enclosed founder populations.

Campbell: The human line has evolved at a remarkably rapid rate. Even in the last 50,000 years, there has been differentiation of the various races, and they are substantially different. They differ by almost a factor of two in height; they vary in an enormous number of ways. I don't see how you can say that evolution seems to have stopped or slowed down.

Social development very clearly is part of what gives evolutionary capacity. It is our science, to a large extent, that has opened up the possibilities. The capacity to evolve has been shooting up in the past thousand years, the past hundred years, the past ten years. I am not saying that you have to look at this in a stereotyped way.

Going back to an earlier topic, I have no reason to think *yes* or think *no* about the idea that the forefront of evolution may be taken over by machines. That may be. What I am saying is that if it did, I would predict that they would have much more capacity for evolving and becoming more capable of evolving than what they replace.

Jeffry Stock: What about human genome engineering? Just as a spider web is a fantastic fiber and may be much better than nylon—probably is—maybe there will be the beginning of the evolution of specialized species derived from humans that have capabilities that you think would be better entrusted to other kinds of biology. It is possible that other kinds of biology might be used for computing and for computational methods. I would consider the possibility that you might be wrong: that it *will* be organic in some sense, rather than silicon.

Jhirad: You are talking about human-generated manipulation and change, but what about change from environmental pollution, from the dropping of atomic bombs, and the mutation from that?

Coates: It will accelerate things. That is all it will do.

Andreadis: Yes, it will.

Campbell: No. I think it won't do a thing, not compared to the progress that can be made from direct germline intervention and systematic, deliberate change. It will be like only background noise. That level of noise may increase a little bit, but I think the big changes are not going to be due to selection pressures from the external environment.

…the distinction between what is going on culturally and what is going on physically, biologically, is going to blur.

Gregory Stock: Yes, we are pretty good at buffering ourselves from those things; we're very capable of that. Along the same lines, the distinction between what is going on culturally and what is going on physically, bio-

logically, is going to blur. There will be tight feedbacks between those as we begin to manifest philosophy and conceptual frameworks within our biology, and those, in turn, will feed forward into the evolution of our ways of thinking and the way we think about ourselves. The forming of those feedback loops is part of what will occur with that divergence.

Coates: What I have heard so far is that we unequivocally will have variations developing, and some likelihood that the variations will amount to speciation. Second, there may be a separate development interacting with variation and speciation, and that is the integration with information technology. Then we had a little bit about the speed and pace at which these are going to go. Is there any new point that anyone wants to add to that triad of concepts?

Jeffry Stock: It is likely, if you have an optimistic view—*or* a pessimistic view—that our population will be much lower than five billion. I am thinking more like several million, because that would be a lot more manageable. Reaching that point would have all kinds of implications. A population normally increases exponentially, which we have done, and then it reaches a stationary phase. In the stationary phase, there is a tremendous decline and diversification.

Coates: What would bring us down?

Jeffry Stock: It is desirable, and we have reached a stationary phase. There is no advantage to keeping our population up. And regions of lower population, like the United States, for instance, have more power.

Palfreman: I don't see how we get around the fact that humans want to be different from other humans culturally. The idea we have here of a sustainable paradise—population declines; world government; everybody gets along with each other—is competing with this notion of speciation, being separate.

…we are going to have rivalries among different subgroups for power and control. This is embedded in our historical genetic baggage.

Zimmerman: I was about to comment on the same issue. We have talked about the world in the future being this benign place where we will have lots of divergence into subspecies or new species. But if French's thought is correct that indeed we will have a lot of changes physically and in terms of cognitive function but no change emotionally or spiritually, it seems obvious that we are going to have rivalries among different subgroups for power and control. This is embedded in our historical genetic baggage.

Coates: Would you see us also having rivalries that were not hostile?

Zimmerman: Not without some change in human nature, and I mean at the genetic level. I am very pessimistic about that.

Andreadis: Actually if you did have these changes, you might have blunting of the rivalries, because you are dealing with cousins now. Although we have wiped out just about everything else that there is on the planet, for different reasons, you would not feel equally threatened if the "other" was "other" enough that you were not competing for the same resources. Here we are talking intangibles; the resource you are actually competing for is "pride of place," in some ways.

Jeffry Stock: Athena, we talk about conflict and everybody trying to be equal, which is what is happening now. If you go, for instance, to Africa, the most different groups in Africa and South Africa are starting to conflict with the West because they want to be like the West. If everybody is trying to do the same thing, then you get tremendous conflict. But if people have different niches to fit into, then I don't see any reason for conflict at all. In fact, there can be mutual interactions that are beneficial.

Campbell: We foresee all sorts of conflict in the short term. If the pace of change continues to increase, we should remain as far away from equilibrium in the future as we ever were. I don't see any reason to believe that the pattern of instability we see in the very near future will change in the far future.

…there is the possibility that human evolution will be cut short…by the possibility of our own technologically induced apocalypse…

Hughes: We are about to go to war to prevent a country that may or may not have weapons of mass destruction from threatening the rest of the world. I don't think there is any plausible scenario where in a thousand years

the degrees of differentiation that I presume will exist will not have within it the potential for apocalyptic consequences. At least some of the groups will have apocalyptic powers that will threaten the rest. Therefore, there will be a series of coalitions and global governance or solar governance or whatever that will have to deal with those threats and establish ground rules about what kinds of apocalyptic technologies and abilities different groups can have.

The technologies themselves could have runaway effects, so we need that kind of governance to prevent accidental apocalypse. And those apocalypses may also pose a threat. I am not a total Pollyanna about this; I think there is the possibility that human evolution will be cut short or profoundly retarded by the possibility of our own technologically induced apocalypse, asteroids from space, or whatever.

Coates: Remember that Jon has an option because he has from the tenth to the fortieth generation to introduce, explain, and dismiss those apocalyptic developments. He can jump over them and move us to the third millennium without necessarily going into detail.

Hughes: The problem is that they get exponentially apocalyptic.

Coates: Let's move around the table again to pick up everyone's second ideas.

…space exploration may be the way to infinitely shelve the conflicts.

Andreadis: This is the moment, since we have deferred it, to say something about space exploration. I think that space exploration may be the way to infinitely shelve the conflicts. If every disagreeing group ends up taking its starship off and doing whatever it wants, then you have the drop in population; you can revert to the clan, Edenic pattern, if you want, and become lotus-eaters on Earth. Each starship will be an enclosed universe and will become something else.

Hughes: And speciation.

Andreadis: Yes. So, the answer may well be that if you end up having human exploration of space, all of these things will come to pass without, necessarily, coercion, invasiveness, or conflict.

Jhirad: The Polynesians settled the islands of Polynesia in that exact same method. That is, when conflict would arise on an island, one group would go off to another nearby island. They sailed across the vast ocean of the Pacific long before Columbus.

Coates: There are two problems you would have to address with that model. Where would the spacenauts go? There is nothing close, let's say, within the order of 200 years' travel.

Andreadis: You would have possibilities like suspended animation. We are now dealing a thousand years into the future.

Coates: It's not a question of the thousand years but of the distance it would have to go. The alternative is that it doesn't go anywhere, but just becomes a permanent residence itself.

Andreadis: Yes.

Coates: It seems to me that it may be too much of a stretch to talk, in a mere 40 generations, of being able to launch a population movement, as opposed to an exploratory movement.

Palfreman: It is the beginnings of space exploration.

Andreadis: It could be if that was determined to be desirable.

Palfreman: You need an extraordinarily wealthy society to do this.

Andreadis: You don't. If you look at what happened in the past human explorations, you did not need a wealthy society. You needed wealthy people who were determined to do it. In some cases, you did not even need wealthy individuals; you just needed people who wanted to do it. The Polynesians went in open rafts without compasses; how many got lost? Many got lost, but the rest of them made it, and it was a heroic journey. In fact, that is perhaps the best paradigm.

Hughes: The necessity of space travel is precisely one of the reasons why we are going to translate a significant amount of consciousness into nonorganic platforms. This meat puppet is not the ideal space-traveling form for intelligence. If you want to accelerate a body to some significant fraction of the speed of light and then decelerate it again, you are going to want something that is vastly more durable than our brain. That is going to be something that is coded in some kind of computational substrate.

Coates: Is there anyone whose second idea we have not heard? Go ahead, Greg.

…our perceptual reach, our ability to process information… will be greatly expanded.

Gregory Stock: My second idea, in general terms, was that our perceptual reach, our ability to process information, which has to do with cognition, and our control over what we perceive will be greatly expanded. That leads into concepts like virtual reality.

One thing that conflicts with the notion of going out toward the stars is that maybe we will just be at home watching television, because the kinds of fantasies we can create for ourselves are probably more interesting in many ways than the physical universe, which is limited by all sorts of laws. This touches on what Jeff was saying earlier about being able to feed ourselves all sorts of experiences using chemistry and things of that sort. I think our control and interaction with our world at a perceptual level will be greatly expanded.

Coates: An interesting point you are making is that we, in some sense, will be less and less animal, because we will be spending more and more time quietly sitting with or doing things with information technology.

Gregory Stock: What I was trying to say is: Look at the popularity of films. Does it make us less animal when we are experiencing adventures in a way that is feeding our sense …?

Coates: It makes you a lot less animal if you are doing that six hours a day. And there are people who are doing that. There are kids at MIT who spend 12 hours a day at the computer. They are addicted to it.

Gregory Stock: What do you mean by "less animal"?

Coates: Animality: the things we do as animals: We walk; we jump; we play; we frolic; we exercise. The animal portion of us seems to be what you are reducing the importance of. Does anyone else want to pick up this point?

Zimmerman: I am struck by the pervasive optimism most people are expressing. There are lots of different ways many of these future scenarios could go at any given point at which we look at them. Some people have suggested an ideal situation in which the world population is greatly reduced. That may obviate the need for space travel, if, indeed, we can behave in a civilized way.

Andreadis: It won't obviate the need for space travel. There are people who are curious to go.

The current governance systems that operate in the world today… are hardly models for what we will absolutely need in the future…

Zimmerman: But that's for a different reason than escaping conflict of two slightly different rival species where annihilation of one of them is an alternative. Going because you are curious and it is an exciting thing to do is a different motive.

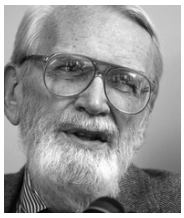
I see human behavior as not unlike the microecosystem of my backyard, which is shared by my three cats, a rather large population of raccoons, and lots of squirrels. Within each of these species groups, they fight fiercely with each other over all sorts of things, but they don't fight between species. If you get something that is close in species, then it is a rival. When we start getting a divergence of the future human populations, they aren't going to be radically different initially; they are going to be very close. I think you are going to find these conflicts and rivalries there from the very beginning, once this starts. If they are going to be handled in a constructive way, it will require much more advanced governance than we have now. The current governance systems that operate in the world today, where we have rampant chaos and death and destruction, are hardly models for what we will absolutely need in the future to deal with these things.

Jeffry Stock: In the past, where we have had closed human populations for long periods of time—which is what we are approaching with a global population—do they work it out and go on for hundreds of years, like in Australia, for instance?

Zimmerman: Usually as soon as they interact, there is rivalry.

Jeffry Stock: No, I mean where you have a single population with no outside group, no Genghis Khan coming over the horizon, do you get a hierarchy? Do you get a division of labor? Do you get classes or castes? Does it work out, or is there a tremendous amount of conflict?

Gregory Stock: I don't know the answer to that question, but I do know that when you start looking at the chaos that exists in the world today and put it on a historical timescale, this is actually a very peaceful, quiet time. It has been 50 years since the last major conflict of global proportions, since major powers were in conflict. Here we dwell for a year upon the deaths of 3,000 people in New York City. We are activated by some bombing that occurs across the globe. This shows how our expectations have changed substantially when compared to what was going on in eras of very high conflict. Our perceptions have changed dramatically. What will happen, I believe, is that there will be continued conflict, but there will be forces—not necessarily global governance—that will keep that within certain bounds, because it will be in virtually everyone's interest to do that.



What is there about us that may in some substantive way be unchanging over a thousand years?

Coates: I want to spin the dial to get you thinking in a different dimension. Please turn to your paper. I want to pick up the point that Barbara Moran would have started us with: As we look out a thousand years, what are the one or two characteristics of people that will be durable through that thousand-year transition? What is there about us that may in some substantive way be unchanging over a thousand years?

Barbara, do you want to start?

Moran: Humans will still want better for their offspring than they have for themselves.

Coates: Notice how that interacts with the artificial womb: Will you really care? Does anyone have anything like that, the high concern for children?

Palfreman: Yes. I can't imagine parents not doing everything to protect their kin, however that is defined. I also cannot imagine people not needing to care about others—nurturing, whether it is young children or not.

Coates: But can you imagine *no parents*? Right now we have a technology of artificial insemination, which means that the uterus would not necessarily have any connection with the fetus.

There will still be parents, whether or not they are biological in the same way.

Palfreman: There will still be parents, whether or not they are biological in the same way. There will still be children you will think of as your own.

Coates: So, Jon and Barbara think that parenthood and children and concern will still be there.

Zimmerman: What won't change is the need and the importance of perpetuation of the species. A corollary of that is, obviously, nurturing and caring.

Coates: I have never known anybody who had a desire to perpetuate the species. Have any of you had that experience?

Zimmerman: It's not in the cerebral cortex. You don't think about it.

Coates: You presented it as if it were a conscious kind of thing. Anyone else on this children/parent issue?

Campbell: I didn't write it down, but I would certainly agree with that.

Velamoor: I don't think there will be any such thing as parents and children. There will be farms for youngsters, with no connection to parents.

Coates: That's very interesting. Of course, it hasn't worked in the places where it has been tried.

Greg Fowler, how about you?

Self-preservation: That we simply continue as a species is paramount in our minds—that we leave our genes to the next generations.

Fowler: Self-preservation: That we simply continue as a species is paramount in our minds—that we leave our genes to the next generations.

Coates: Okay. Does anyone have an idea related to that one?

Jeffry Stock: Yes. We will still have death, which presupposes a more fundamental thing: that people will still have a finite lifetime. And the other one was taxes.

[Laughter]

Jeffry Stock: … because you have to produce for the society.

Coates: Will death be a subject of mourning or celebration—or neutral?

Jeffry Stock: It will be just a basic fundamental.

Coates: All right. Greg?

Gregory Stock: I think there will still be strong conflicts for status and resources. That is inherent.

Coates: At the individual level or the social level?

Gregory Stock: At the individual level. It manifests itself at the social level as well, but it emerges from struggles at the individual level.

Coates: How will that work? Here I am in the year 3000 in my neighborhood; what am I going to do? How is my life going to be structured around this acquisitiveness?

Gregory Stock: Think about the way you are now: You struggle to do things so that you get certain amounts of feedback that are gratifying or that elevate your status relative to others around you. You do things that give you resources and control over resources, whatever those resources are.

Coates: Today the primary source of control over resources is work. Are you suggesting that there will be work in the third millennium?

Gregory Stock: Work is one way of controlling resources. There are many ways of controlling resources: by gaining influence over other people, by forming alliances, by forming friendships and relationships, by inheritances, by many ways.

Coates: Those are all in the context of today. As you see it, how will the day-to-day, week-to-week, month-to-month needs of ordinary people—presumably food, clothing, shelter—be satisfied? Will we have a uniform leveling of everybody? Will there be differences in it? If there are differences, what will entitle a person, and who will distribute these things?

Gregory Stock: I think there will continue to be many differences. I don't know what those resources are. If you are having conflicts for resources that are computer cycles, it is very different from conflicts for energy. It manifests itself in whatever the substrate and form we are in. It is an inherent aspect that is at the root of the evolutionary drives that John Campbell is talking about. And I believe that will occur, simply because those entities that have that within them will acquire more resources and will be dominant.

Coates: Any other comments on *viva la* Calvinism?

Palfreman: You will compete for whatever is scarce. You have to believe there is scarcity of certain resources. On *Star Trek* there are replicators, so you can make things, but there is still something that is the scarcest product in the universe. It doesn't matter what it is, so long as it is scarce.

…if you take away all desire, that kind of life will be selected against. Whatever life exists will have to be life that desires something.

Hughes: That reflects my own Buddhist biases. One thing I think is inevitable is that as long as there is sentient life, there will be desire, and as long as there is desire, there will be suffering. Whatever those future beings desire, there will be frustrations; there will be limits. I don't think any of the particular desires you have mentioned are immutable. The desire for progeny and the desire for particular resources will all be things we will have under our control, but if you take away all desire, that kind of life will be selected against. Whatever life exists will have to be life that desires something.

Jhirad: One more thing to add that will be there in the future is hubris. It will continue to be, I think, a major player in the human species. Overconfidence with the gain in technological prowess has done us in before, and it will do us in again. I keep thinking of Kagan's *On the Origins of War* and some other films I have done that looked at the late 19th century when we had various expositions of the technological advances: in St. Louis, the Chicago Exposition in 1893, and another in 1904. They were looking at the future the way we are now, but they had *no* idea how terrible it could be until World War I came around—that these great achievements could descend into such terrible destruction. So, I think hubris will continue to plague us.

If we were…content with not understanding, we would not have monkeyed and tinkered around with ourselves to the point where we stopped being monkeys.

Andreadis: You can call it *hubris* if you like, although frankly I think technology—it's always a dual-edged sword—has actually helped us more than it has hurt us, but that is another discussion. Along with hubris, humans want to make a difference. Along with that goes the desire to know, a desire to push boundaries, a desire to open up and understand more and more of the universe. That, I think, is always connected with hubris. If we were humble and we were content with not understanding, we would not have monkeyed and tinkered around with ourselves to the point where we stopped being monkeys.

Coates: What would you see making a difference in the year 3000? What would be the opportunities to make a difference?

Andreadis: Make a difference in ourselves; make a difference in the universe.

Coates: In other words, a commitment to change, as opposed to "make a difference"?

Andreadis: A commitment to change informs your mindset. It is something that is an assumption.

Coates: But when you said, "Make a difference," perhaps erroneously I associated "making a difference" with some sense of betterment for other people, not that you are going to make yourself better.

Andreadis: That is part of it, but not all of it.

Coates: How exactly would you benefit other people in the year 3000? What is your picture of how to engage in betterment?

Andreadis: Let me give you an example. I am doing what I am doing here as a scientist. I left my culture and my adoring parents and my comfortable, upper-middle-class existence in Greece, and I came over here where my name is constantly mispronounced because I thought I *could* make a difference; namely, something that I discovered would be important enough that it would change the flow.

Coates: That is today. What would be the parallel to that in the year 3000?

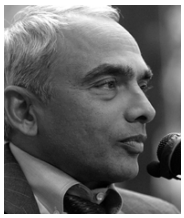
Andreadis: The parallel would be—let me give you a *sine qua non*—to create an engine that would allow the universe to forever renew itself.

Hughes: Stop the heat death.

Gregory Stock: What Athena is saying is that at whatever stage things are in the year 3000, it would be clear what one could do to contribute to that process.

Coates: But let's get to the concrete: What would that actually involve? Jon will have to deal in the concrete, not in the abstract, to make this film. He has to have specific imagery.

Gregory Stock: That has meaning only if you have the context, if you create that world, which is a far more challenging task. Then you could say what has meaning. To contribute to the process even 150 years from now is very hard. You can talk in abstract terms, but what people do concretely is very specific.



What will be the remaining frontiers of knowledge?

Velamoor: Maybe the question ought to be: What will be the remaining frontiers of knowledge?

Coates: Sesh can always come up with a good question. Does anyone else have a point on this? I want to be sure we hear everybody's best notion.

Jeffry Stock: We will not have, as individuals, the same global view that we do now. It is a peculiarity of our time that we are even thinking about what is going on in Iraq. In the future, a thousand years from now, we will be much more realistic and say, "I am concerned with what is going on in my very local environment." I am not going to be spending a lot of time thinking about somebody who is going off into space, because that won't be relevant, necessarily, to me. I don't know why everybody has eschewed this concept of the ideal environment, the Eden situation. Someone said it would be boring. That's interesting that we would say that now we don't want to go to heaven; it's a terrible place because nothing happens there.

Palfreman: The idea is that Edens have been tried and they have all failed.

Coates: Including the first one.

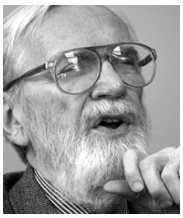
Palfreman: Yes. You build a city in the middle of a country and you make it all equal, but it becomes unequal. Every time it has been tried, it seems to be just a romantic fantasy. That is where the cynicism comes from.

Zimmerman: An enduring characteristic of humanity in the next thousand years will be the continued curiosity about nature and oneself and the universe—in other words, the driving force behind science.

Coates: Do you think that will become generalized to everyone? Obviously not everyone has scientific genes.

Zimmerman: It might become more widespread than it is now.

Hughes: I still believe in Maslow's Hierarchy of Needs. Work, as we know it, will be unnecessary well before a thousand years. The majority of people will be pursuing needs that are of a higher nature: curiosity, self-betterment, self-actualization.



Of all those things that are extremely important in humanity today, what is also fugitive, or changeable?

Coates: There is a charming film of H. G. Wells's *The Time Machine* in which all these people in the Elysian Fields are visited. They are the "real" people while underground are the Morlocks. The Morlocks clearly had a more interesting life than the people in the Elysian Fields.

I would like to flip the dial once more and ask you the following question: Of all those things that are extremely important in humanity today, what is also fugitive, or changeable? We have talked about what is unchangeable; now, what is there that is important about humanity that is, in fact, subject to radical, substantial change?

Hughes: Do you mean something that we would want to preserve but we think is threatened?

Coates: Whether you want to preserve it or not. For example, insanity is part of humanity's story today. Now, I think that insanity is completely changeable, that we will eliminate it, and that will be good. The point I am getting at is: What else is there in the pool called *humanity* today that is important and that is also changeable, maybe for the worse, maybe for the better. Let's all take a minute to write it down so that we don't let the discussion be dominated by the first two or three items.

You will each have about 30 seconds to present your notion.

Sleep.
We will figure it out, and we won't have a third of our time spent unconscious.

Jeffry Stock: Sleep. We will figure it out, and we won't have a third of our time spent unconscious.

Coates: Maybe we could enrich sleep, and make it more fun.

Jeffry Stock: Well, it's fun now; I like sleep.

Gregory Stock: The focus on our common nature of humanity and what the boundaries of humanity are. We are all separate from nature around us and yet at the same point distinct and the same.

Coates: What is going to happen to the boundaries?

Gregory Stock: They are going to become very blurred in all directions: that sense that humans are aware of where consciousness resides, that humans are separate from their natural environment in deep ways—genetically and in every other way. There will be great diversity among us and there will be great penetrations into these other realms.

Coates: So, zoophilia might come to be an important new consideration, or phytophilia: We love our poison ivy; we love parrots and rats …?

Gregory Stock: We were talking about there being consciousness in other creatures, about there being artificial intelligence that has aspects of who we are. That would mean great differences among us, not uniformness.

Coates: Certainly an interesting development.

Andreadis: Actually I wrote something very similar to that. I said basically that the definition of *other*—which is important but will change—has changed significantly, even within the last few years.

Moran: What I wrote down is much more mundane, but very important in my own life, which is food. Cuisine could be lessened—you see it happening with PowerBar®.

Zimmerman: As far as characteristics of current society that are entirely dispensable, I would say greed is the driving force of capitalist society. We can certainly do without it, and I hope we figure out a way to get rid of it.

Coates: This is at odds with the acquisitiveness that we heard about earlier.

Zimmerman: Not necessarily. I don't think it is. I had acquisitiveness as a desirable trait, and I don't think this is at all incompatible.

Coates: You are saying greed is going to disappear?

Zimmerman: I'm not saying it is going to; I am saying it could and that society would be better off if it did.

If I could comment on the idea of sleep, I would maintain that sleep is an integral part of the creative process, at least from my own experience, and I would really hate to do without it for that reason.

Gregory Stock: Would we be able to do without waking? That is the question.

The most challenging thing that we will evolve away from is the importance of our own personal continuity.

Hughes: The most challenging thing that we will evolve away from is the importance of our own personal continuity. As we are able to share experience more profoundly with other collectivities, we will increasingly feel a sense that our continuity is less important than the continuity of those collectivities.

Fowler: Living in a world of intelligent machines, I think we are in great danger of losing the ability to chart our own course: the roads we are going to go down, what we are going to do with our lives. We are going to be in serious jeopardy as to being able to make those decisions.

Gregory Stock: Do you mean as individuals?

Fowler: As individuals, yes: technofixes, technocrats making decisions for us.

Palfreman: I think we could make a stab at moderating violence. It is something we all agree is bad, so it is not inconceivable that in a thousand years we might be able to do something about that.

Coates: Isn't that an element of the 250-year scenario, where genetic intervention would deal with it? It seems to me that belongs back there. There are obviously brain systems that lead to a short fuse, lead to violence, lead to intemperate behavior, and they are coming to be identified. Almost surely there will be interventions, perhaps in the next five to ten years.

Palfreman: For everybody?

Coates: Some people are more violent than others.

Velamoor: I don't know how you do that to entire cabinets and presidents, though.

Coates: John, how about giving us the last one?

…particular dogmas and myths will change, but religion is still going to linger on in one form or another.

Campbell: Religion. Sure, particular dogmas and myths will change, but religion is still going to linger on in one form or another. Also, the psychology behind it is something that will always be with us.

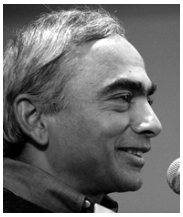
Coates: Okay. Back to you, Sesh.

Velamoor: Thank you. We are adjourned until tomorrow morning.

Revisiting the Preliminary Outline

Following focused discussions on possible scientific and technological advances in three time frames of the future, the participants returned to consideration of the Preliminary Outline for "The Future Human" program.

Discussion Leader: Jon Palfreman



First we will revisit the treatment for the program in light of all the discussions we had yesterday…

Velamoor: Good morning, everyone. We have two sessions today. First we will revisit the treatment for the program in light of all the discussions we had yesterday, and see if we can provide feedback to Jon to go forward. In the second session, which is probably the best part, each of the scholars will have five minutes to articulate his or her own view about future humans without anybody interrupting.

At this point I will hand the meeting over to Jon so he can coordinate the conversations on the treatment.

Of all the enhancements, the one that seemed to be the "killer" application in the mid-term, 250 years, would be cognitive enhancement for the elderly…

Palfreman: Thanks to everyone for yesterday. I thought our technique of dividing into three bits was helpful in constraining the discussion to some extent. In thinking afterwards about what we had learned, I thought the first session was extremely useful. The short-term future, the 25 years, seemed to be very exciting, and it set my expectations very high for the other two discussions. Interestingly, and I was trying to puzzle why, I did not enjoy the other two sessions as much as the first one. The session I enjoyed the least was the one everyone was hyping, which was the third session. When I look at my notes from the third session, they are totally fragmented and not very useful.

The first session had a lot of ideas coming out of it. The second session—I don't think we quite nailed it, but we had lots of good material in it. And then the third session didn't really get there. So, this morning I am looking for help in thinking of that time frame.

Also, there seemed to be a complete disjunction between the second and the third sessions. In the second session, we made a start at talking about longevity, reproductive enhancements, nonhuman factors, and mood issues, and we talked a bit about a generation of subgroups. By the time a thousand years had gone by, we didn't talk that much about longevity. Half of the group seemed to have adopted a utopian position; somehow the subgroups and all these things that were problematic at 250 years had gone away and we had an ideal society and a world government. We didn't talk about speciation very much, and we didn't engage much with the notion of what it meant to be human a thousand years out.

We were quite aggressive at 25 years. Some people felt that we were a little bit conservative at 250 years. Maybe we were just tired, but we didn't get far at a thousand years. What worries me the most is that we didn't link the three parts. If we have got this right, we should be able to link some of these things together.

We could talk a bit more about some of the issues. For example, longevity: We were playing with ideas in the first session and we were talking about increasing the life expectancy to 100. In the second session, we were talking about a bit more than that, but then Walter came in with a quite interesting point: "What does it mean to live long if you can't live with high function?" So, the issue of cognitive function came up. Of all the enhancements, the one that seemed to be the "killer" application in the mid-term, 250 years, would be cognitive enhancement for the elderly, which might enable this decline to be more graceful. But it seems to me it

would be worth following that through to the thousand years. One of these issues is: If we could live longer, do we want to live longer? There are huge issues about what it means to be human that have an effect, depending on whether we live 80 years, or 150 years, or, as somebody suggested for a thousand years out, 250 years.

The speciation idea and the subgroups I didn't quite get. I wasn't clear what would define success of a subgroup. We were talking about cults, almost like little groups that might want to promote their own evolution by presumably using artificial chromosomes and keeping their evolution going in a particular direction. What would prevent that being copied, and what would determine that one group would become more influential than another group? It couldn't just be, as in classical evolution, the success of the species, because people who are very rich and influential don't necessarily want to breed a lot. I wouldn't mind a little more discussion on that.

Those are my thoughts, and I want to leave it there for now, but it seemed to me that after everything that was said about the 40 generations being the most exciting, we just didn't get very far there. The most exciting time frame for me was the 25 years, because it was grounded in something tangible. It was specific, and we could go back to French or other people and do reality tests: "How credible is this?" We could sort through that at 250 years, but at a thousand years, there was very little consensus in the room. Someone would say something, and someone else would say the opposite. It wasn't very helpful to me.

Velamoor: You are saying that the 40-generations material needs some work; there is a disjoint between the second time frame and the third; and you would like to stay focused on those three main issues. One is longevity, related to not only how long, but also cognitive function and differential aging. Second, if there were to be subgroups, what kinds of subgroups? In what form will they be organized relative to each other? And what constitutes success for these subgroups so that the totality still remains a functioning entity? The third was: What does it mean to be human?

Palfreman: Yes. I would be interested in hearing other people's reflections on yesterday's discussions and what surprised them about what was said. Please be as specific as possible.

…all of the foments we foresee for the next generation are also going to be expressed at the 250-year mark and at the thousand-year mark.

Campbell: Regarding the relationship of these three periods, my own feeling—and I suspect it would be the feeling of a number of us—is that all of the foments we foresee for the next generation are also going to be expressed at the 250-year mark and at the thousand-year mark. Whatever activities we can see for that interim period, the later periods are still going to have those same things, except there will be additional things to it.

Coates: As a working futurist, I have to say that your disappointment is absolutely to be expected, because what you are asking and expecting everyone in the group to do is utterly unrealistic on a first pass. You are expecting them to deal with concrete, pictorial kinds of things, when they have never thought about that in any serious, extended way. It is a practice effect: You have to work at it to get this stuff. Let me give you an illustration. You may remember that I pushed pretty hard on Greg yesterday to go from the abstract—nothing wrong with the abstract—to the concrete. I must have asked him five times, "Get concrete!" Same thing with Athena, and they couldn't do it. That doesn't mean that we shouldn't focus on the points they were making and then look at how that would show up in a concrete way.

Barbara suggested that we look at what is durable in humankind, and then later we looked at the question of what is fugitive. Those are the clues to what we have to play with to develop the concrete, and that is what you should have been paying attention to: What is durable for a millennium and what is fugitive or plastic for a millennium?

The longevity material, to me, is utterly uninteresting, if it is only a matter of 75 years or twice or three times the life expectancy. What we want to get at is the question: What is a person's behavior day like? What will an individual do throughout a day? How will they have recreation? What will they do with their leisure time? We could all agree that there is going to be a lot of leisure. What is the role of the arts? The performing arts, the creative arts: How will people be involved with that? These are the questions we have to address in a very specific way.

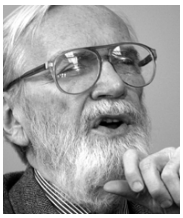
Palfreman: But they might not be in this episode. We have several episodes, and material to do with work and leisure may be in another program.

Coates: For the moment, that is your problem. I am addressing the very serious concerns you had of the subject of the third round being dry. This is absolutely to be expected, and I am suggesting the way you have to get past the dryness, and it is concentrating on the individual life of a person at that time.

Let me suggest that the central feature here—because we did have consensus on this—is that there is going to be relatively little work, in the 20th century sense, and relatively large amounts of free time. That is the playground in which we should be working.

Palfreman: I don't think we agreed on that.

Campbell: Not at all!



…we may very well be past all of the traditional conflicts that seem to shape our thinking and our everyday news.

Coates: Well, all right. If you look at what went on in the question of longevity—what are you going to do if you live twice as long? That is a lot more time than we have today. How is that time going to be consumed?

Implicit in your critique was that there must be competition among different groups. I don't see, for example, any competition between high-paid Hollywood actors and Wall Street financiers. I don't see any competition between being a physician or a surgeon and being a historian. You can have quite distinct groups without this 20th century carryover of conflict. One of the interesting things is that we may very well be past all of the traditional conflicts that seem to shape our thinking and our everyday news.

These are some thoughts on what you should be concentrating on. The abstract to the concrete is your single most difficult question.

Gregory Stock: I shared some of Jon's responses to yesterday, in particular that we were very aggressive in looking at what happens in the next 25 years, and then the discussion seemed to get very conservative. This is a ten-fold increase. It seemed to me—especially in the realm of longevity—that it comes from the fact that the people in the room were talking about things that they would like to have in a time frame that is meaningful to them personally. I found the projection of a 100-year life expectancy over the next 25 years to be astonishingly aggressive. I was actually very surprised by that. As soon as we began looking out a number of generations, then we were thinking of the things that might block the progression, or perhaps we didn't want to be wrong, but the discussion became very conservative.

I would disagree that the issue of longevity, of itself, is not very interesting if it is only doubling or tripling of human life span or adding 50 percent. It is completely separate from the notion of what our lives would be like. If you talked to people a hundred years ago about life expectancy and they said, "You might live until you are 80, but what I want to know is what you will be doing on a daily basis," that is a very different issue. That is a very different challenge: what the tone of life will be like as opposed to how long it will be in a healthy fashion.

In terms of a discussion of cognitive function, there are two aspects: One is just a maintenance of cognition, maintenance of the functioning individual. We are talking about a prolongation of health span, rather than an extension of life span and prolongation of decrepitude. I think that no one would be interested in extending a life that isn't a vital life, one that isn't mentally agile and full. The enhancement of mental function is a whole other issue; it is a separate notion of expanding beyond the capacities we are dealing with today. That seems to me to be a wholly different thread that wasn't there originally. I think we should talk about the longevity issue, which is a very difficult one to deal with. I think there is a potential for serious extension of health span.

Palfreman: Greg, would you also address my perceived mismatches between the second and third sessions?

…our projections about the future…are so much colored by our own hopes and fears and concerns…

Gregory Stock: In the third session, Joe was pushing us to be concrete, but I think the idea of being concrete about the thousand-year future, when there are so many variables that could go into it, is somewhat of a joke. Even if a person tried, it would be a random level of concreteness. If I made a concrete scenario, it would be merely a projection of whimsy, essentially. To me, there was so much disagreement because there was not an effort to probe particular ideas. Each person was simply

writing down something he or she thought was important, and I think that was the reason for the lack of coherence. There was a divergence of possibilities at that stage, and it is a hard level of connection.

Finally, one thing I came away with was the strong degree to which our projections about the future—especially as we go forward further, but even in the near term—are so much colored by our own hopes and fears and concerns, as well as by politics and our feelings about the present and who we are. That is something very important, because it makes us take it just a little bit less seriously. It is almost like a Rorschach. It became predictable what people were going to comment about different things. There were themes that continually reappeared. That is important, because that is exactly what is happening now in our discussions about future technologies. It is really a manifestation of who we are in the present.

Coates: You are missing something very important about our sponsors. The whole theme of the Foundation For the Future is humanity in the future. People. If what people *do* is not the essence of humanity, then what is the essence of humanity? When I pick up a *National Geographic*, what do I find there? I find the life of people with whom I am unfamiliar, and I don't want to see that they lead the same life I do; I want to see how their life is different from mine. When I go to see a documentary film, I am not interested in how much their world is like mine; I am interested in how their world is different. That's how we work in a cultural context.

Now we are working in a temporal context. If we are going to engage people's interest in the year 3000, it can't be in terms of the abstract notions that might fit in an almanac. It's got to be in terms of how individual lives are different. So, I fundamentally disagree with Greg on this point. If we are not going to show how individual lives are different, we are completely missing out on what you might look at as a form of future anthropology. If we can't describe that world and how people live in it, then it is going to be as dry as dust and have no impact on people.

What is the life cycle of people? What is the day of people? What are the parallels and what are the dropouts from the things that characterize our own human behavior?

Gregory Stock: But, Joe, you were making a strong plea that you didn't want us to engage in science fiction. Now you are talking about making up a story about a family or a person a thousand years into the future. I don't say you can't do that; I could get very specific about what they are doing throughout their entire day, and it would be nothing but fantasy.

Kirk Citron: In terms of the overall structure of the series, this one is on "The Future Human," which is, in my mind, mostly concerned with what form the human body will take: What forms will our consciousness be put into? I think you could make some guesses or projections about the range of possibilities for what a future human body is going to look like and what that means for human nature. That is what I would ask people to respond to.

Andreadis: I would like to talk to Jon the way I would actually talk to a television producer, rather than in big ideas. First, you want a recipe for this series. You want a "closed something" in the end: somebody who will go out and say, "Now, having heard all of these things, this is what the future will look like."

Palfreman: I want some content. I am not asking for much. I am looking for some specifics.

One of the things you will have to reconcile yourself to is the fact of the "noncollapsed quantum function": You are going to have futures, not future.

Andreadis: One of the things you will have to reconcile yourself to is the fact of the "noncollapsed quantum function": You are going to have *futures*, not future. The problem you have is that neither you nor we can put "killer" visuals on it yet, because a thousand years from now … it diverges as you go. It gets more and more divergent and vague as you go.

The other thing that happened here is that we didn't have enough time. One day is not enough to sit down and figure out specifics. People are afraid of being called a Nazi if they stand up and say, "You know what I would do? I would coerce everybody to enhance themselves." People would gasp. You cannot have "warm and fuzzy" at the same time. It is either controversial or warm and fuzzy, not both.

Palfreman: We are not talking about "killer" visuals; we are just talking about my response that we didn't link the third session to the second, and we didn't get very far in the third one. It just wasn't very interesting, not even thinking of visuals. We didn't get many specifics.

Andreadis: You will get many specifics, but they will each be of a divergent vision. In the end, you have to be willing to say: Here are four possibles, or six possibles—and describe them, if you want, with the people who espouse them. The closure is going to be that there will be many possible futures.

Palfreman: I am not disagreeing with that, but I think we didn't even get very far with those visions. There is not much even to choose among them.

Once we have the ability to back up our personalities, to share our personalities, to copy our personalities, we have achieved functional immortality.

Hughes: The question "What is a human being?" is one of the places we have to go back to. I presume that if our ancestors from 40,000 years ago saw some of us today, they would not recognize us as necessarily the same species. They might think that Neanderthals were closer to them than we are. I presume that in the future, a thousand years from now, there will be some beings that today Francis Fukuyama would say are posthuman, but those people will still say, "I'm part of the human family; I am part of the continuity of humanity."

Just in terms of what people today might think about when we pass beyond the boundary of human to posthuman, I think that clearly in 40 generations, the majority of our descendants will be posthuman, so that will be "the posthuman era."

In the second period, what I would call "the transhuman era," there will be some posthumans; there will be people who are genetically enhanced beyond what many of us would consider to be "Human 1.0"; and there will be some degrees of cyborgization. At that later period, there may still be some people who are unenhanced, some Amish who decided never to take advantage of any of these technologies and still have 70-year life spans.

If that is what we are going to restrict it to (what is the future of human beings *qua* Amish?), that is one thing; if it is: "What is the future of human intelligence and the descendants of human intelligence?" that is an entirely different thing. As Greg was saying, one of the key questions here is: What kinds of enhancements of cognitive function are we going to be able to do in the second and third periods? Again, I think brain augmentation, brain prostheses, the biological enhancement of cognition, and the ability, eventually, to upload and download personality elements and have complete control of memory, identity, and so forth: Those will be features 40 generations from now and will create profound effects on our understanding of self, identity, citizenship, collectivities, and so on. Once we have the ability to back up our personalities, to share our personalities, to copy our personalities, we have achieved functional immortality. Whether people still *feel* that that is a continuity of personal identity or not, when they don't have necessarily the continuity of their biological existence, that is a different question, but I think most people will be satisfied. If they feel that they go from this state to this state to this state, if they *feel* that personal continuity, they will feel that that is functional immortality.

Palfreman: Yes. I seem to recall that you thought that the Kurzweil scenario would come in at 250 years, so you are definitely certain it will be done by a thousand years.

The competition for resources between Humans 1.0, posthumans, and nonhumans will be profound, and whoever has the best augmentation is going to win.

Hughes: Yes. I am a sociologist, but almost everybody else at this table is a biologist. If we had Hans Moravec here, if we had Ray Kurzweil, if we had some computer scientists at the table—I know that almost all the computer scientists would be saying, "This is going to happen in 50 to 100 years. We are going to have computers on everyone's desk that will have a million times the capacity of a human brain."

Whether the problems of software engineering for artificial intelligence are profound or not, by 100 years from now, we will have functional artificial intelligence. We will have self-willed machines with which we can have a conversation of some kind. Now, they may be profoundly inimical to human existence; they may be something that we have to control in a very authoritarian way. The question, for me, is not whether we will have nonbiological existence—this gets to the competition point—the question is whether it will be *us*, in that nonbiological existence, or *them* in that nonbiological existence. We are going to have competition for resources, and some of us will put ourselves into those posthuman states. The competition for resources between Humans 1.0, posthumans, and nonhumans will be profound, and whoever has the best augmentation is going to win.

Velamoor: Just to recap, it seems to me that we are coming back to those three divisions we had proposed: corrections, improvements, and enhancements. I think J. [Hughes] is defining three phases from the 250 to the thousand as the *Homo sapiens*, *trans-Homo sapiens*, and *post-Homo sapiens*.

Coates: J.'s point is very interesting, but it is as dry as dust. Let me explain. I have a five-dollar calculator. I can do square roots the old-fashioned way. I actually sat down one day to figure out that the five-dollar calculator does square roots one thousand times faster than I can. Now, I was doing only little square roots, not big numbers. There is nothing that suggests that that five-dollar calculator is more intelligent than I am merely because it can do a job a thousand times faster. In the same way, if we have a million times increase in the capacity of the computer, it still does not imply that it is more intelligent than I am, that it somehow overrides every one of my capabilities. Unless you can show me the specifics of how it is going to override, tell me the specifics of what it means to be more intelligent than I am, give me the ideational imagery of what it is going to be like, it is as dry as dust.

Now, in terms of what you are talking about, I could picture a situation in which I want to look at that ancient Cambodian stuff and I have a little insert I stick into a cell in my head, but unless you are going to talk about that and show that going on, and then show the inside of my head—what I am seeing and interacting with—all you are doing is giving me an abstract idea. What you need to do to make this valuable to Jon is to show how that intelligence will, in fact, influence the human being's day-to-day behavior. Without doing that, it is just another abstract statement like "it's cold in the Arctic."

Technology is for us. The real question is: What do we want to use it for? The technology isn't going to run away with itself.

Jeffry Stock: I disagree. I think you are running away with technology. Technology is for us. The real question is: What do we want to use it for? The technology isn't going to run away with itself. It is similar to the drug situation. You can imagine drugs that would make you perfectly happy, perfectly satisfied, perfectly everything, and they probably exist right now. But we don't do that. We don't indulge ourselves; we limit our indulgence in those things. I think technology may become less. I think it *will* become less. Right now it is a crude technology that we have to interact with for the needs of the hugely overpopulated world.

Palfreman: Could I ask Athena about the concept of the transhuman? Do you have any thoughts to contribute on that?

Andreadis: There is no question that we are clearly dealing with what constitutes *human*: human, posthuman, nonhuman. If you are asking whether we can upload or download and still remain human, the answer is: Not as we know it. Let me give you an example. A vast amount of our brain is taken up with doing our autonomous functions. There is the story of the centipede that was asked how it walks, and it fell over because it thought about it. All of our autonomous functions are done without our knowledge, really.

Now, the question is: What is going to happen to all of that part of the brain when it no longer does something? You could actually have it going crazy, because it is flailing for connections that are no longer there. This is a legitimate question in biology, as a matter of fact. The answer is: I am not sure it is doable for us, as biological entities the way we are today. But if we succeed, what we will create is something that is not quite us.

Palfreman: On this notion of downloading, do you think in a thousand years … are we talking about something that is like breaking the speed of light, that is too far out there?

Andreadis: I would hedge my bets on that one. I am not sure. The extent of downloading may be limited by the chassis.

In this dichotomy between us and them, we need to see ourselves as extending beyond the envelope of our skin.

Gregory Stock: In this dichotomy between *us* and *them*, we need to see ourselves as extending beyond the envelope of our skin. We use technology in ways that are extensions of us, and we identify with that. We would feel very different if there were no technology we were using. The nature and intimacy of that connection are going to change. We will have an increasingly intimate association. I am not sure there is much of a difference

functionally between having some implant that is internal and one we are associated with very closely that is feeding images into our normal sensory channels. The incorporation of mechanical and electronic aspects is the notion of the cyborg, and the fyborg is the functional cyborg.

As we move into the future, the expansion of ourselves will be that we are surrounded by this buzzing whir of hyperintelligent machines of one sort or another, at least very strong computational devices.

Jeffry Stock: I don't see why that is true. If leisure goes up near 100 percent, what do we want machines for, as long as the job is getting done? I like to walk to work; I don't like to have the cellphone with me all the time. Most people, I think, are like that: They want to get rid of this necessity to be constantly bombarded by all kinds of trivial information. We are human. We are not going to change in a thousand years. If you look back a thousand years, you can read people's writings from that time, and I can relate to what they are thinking. A thousand years from now, why would we want to change? Why would we want to cut out love? Why would we want to cut out everything we value and become machines? If that happens, it will be another species that takes over humans, and we will no longer be human.

Walter Kistler: I think you are right.

…if you have two species trying to compete in the same niche, eventually one wipes out the other one. This is a very real concern…

Zimmerman: I think Jon's perception of the third session was right. We need to make the connection, as a continuum, from what we can foresee in the immediate future (the next 20 or 30 years), through this intermediate zone, and really get serious about what is likely to happen. Some of the discussion here about cyborgs and fyborgs, etc., is almost beyond science fiction. I agree with Jeff: What would the motive be? I think there will be a lot of experiments in genetic enhancement within the next 200 to 300 years, and then we have to deal not just with what is the desirable product, but the fact that these are going to exist in the social environment. According to current Darwinian models, if you have two species trying to compete in the same niche, eventually one wipes out the other one. This is a very real concern, the notion of Hollywood producers and so on notwithstanding. Once fear is an element, if there is perceived to be competition or domination, unless we wipe the slate clean and change the limbic system and all the bases of our motivation, we are going to have these problems. And we are going to have them in spades the more we create subgroups of genetically modified people that are seen as superior in one way or another: more intelligent, longer lived, maybe physically superior, free of disease. These are all desirable goals, but let's not lose the perspective of the context in which these creations will exist.

The other thing that disturbs me a bit about the discussions is that they are still somewhat centered from the perspective of the United States, which represents less than five percent of the world population. We have to take into account that we are not the whole show. We are, in fact, a minority of the show.

Andreadis: If I may address this point, because it is important and actually I am one of the aliens. I wasn't born here; I came here when I was pretty much an adult. There are some things that are, indeed, unique to the United States, but I will tell you what is not unique. When I was a kid and televisions were still things you saw in the stores, I watched the moon landing. All of Greece was watching the moon landing, even though this was a time of military junta. This was seen as the human achievement—not the American achievement, but the human achievement. There are some things that compel humanity—the myths, the legends—and these are ours. These are the legends of today and possibly of the near future.

One of the things that Westerners have done is that we have gone to the tangible: the quality of life, the remote control. We will thrive as a species if we have some kind of horizon ahead of us. Otherwise, we tend to revert to the kind of thinking that says, "Our fathers were happier; let's have fundamental religion and the women back in the kitchen." For us to go forward, we do have to have a goal that is *not* tangible, that is some kind of dream. Some of the dreams unify. Whenever I have been to a launch, you see blue-collar workers, grandmothers, babies … and they look at this thing going up (phallic as it is; it doesn't matter) and they all react: "Ah!" There go the dreams. This thing is powered by its engine, but it is fueled by our dreams.

It is not just a Western thing. I came from a relatively low-tech society; granted: It was a nation that had a glorious past. But these are *my* dreams. It is like people saying that the Chinese cannot think of democracy, but *I* think of these dreams and I came from one of those countries.

Velamoor: I am another alien here who would oppose that. When I go back to India during the winters, I go into the rural areas. It never ceases to amaze me: The people may not have seen anything technological, or barely, minimally technological, yet something new completely fascinates them. There is no doubt about that. And, beyond that goes the need, the interest, and the desire to possess, if it is possible.

…the very core human emotions. That, to me, is what a human is, and that, to me, is something that is not going to change.

Anderson: It is certainly fascinating to listen to all this. I spend a certain portion of my professional life dealing with what I would call "the core human," where people are concerned about the life and welfare of their child or of their spouse—the very core human emotions. That, to me, is what a human is, and that, to me, is something that is not going to change. You go back a thousand years; you go back two thousand years; you go back three thousand years; that is not going to change. J. has all these neat ideas that there will be cyborgs in a thousand years, and maybe there will be, but human beings are going to be human beings for the things that are important, the things they love, the things that—when all the neat things are out of the way—are the core things you will give your life for. Those things aren't going to change.

Moran: Which are what?

Anderson: Your children, your loved ones, in many ways your spiritual beliefs, whether you call them political beliefs or you call them religious beliefs. The things that are of core importance for who and what you are: That really doesn't change.

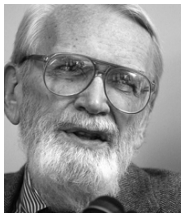
Andreadis: Love, honor, and glory. Those are the three things humans want.

Anderson: I am involved in international sports. You talk with athletes from other countries—in many cases you can't even talk because you don't speak their language and they don't speak your language, but you still can communicate. Human beings are human beings the world over. There might be cyborgs in a thousand years, but we are still going to be humans.

Velamoor: In a sense, they will be no more than extensions of us, like an automobile or a space vehicle or other technological enhancements, but we will remain who we are?

Anderson: Yes.

Gregory Stock: One way that technology disappears is that it becomes transparent; it fades into the landscape, just like electricity does. It is not even thought of as technology. We are in a very awkward stage where technology is so apparent to us because the interfaces are so poor and so rudimentary. I think it will fade away. There can be massive amounts of technology, yet at the same time a feeling that one is living a simple life.



I am seeing Cro-Magnon (us) in 40 generations as still being Cro-Magnon—with some very interesting bells and whistles.

Coates: I would like to suggest a thematic element we might want to consider. We are still Cro-Magnon people. The discussion seems to center, in one axis, around: "Will we still be Cro-Magnon people 40 generations from now, or will we somehow become something different from that?" My own feeling is that 40 generations is a very short time in terms of everything we know about evolution.

I am seeing Cro-Magnon (us) in 40 generations as still being Cro-Magnon—with some very interesting bells and whistles. In the same way that we are different from Cro-Magnon, Europe, the year -10,000, we are going to still be Cro-Magnon with some new bells and whistles. Now, that gives a sense about what we have to look at. Those bells and whistles become the important thing promoting change.

Yesterday Jeff made the point that world population in the 40 generations is likely to dramatically shrink. But even if it does shrink from the nine or ten billion forecast for 2050 back to three or four or six billion, we still have to consider the fact of how many bells and whistles can the rest of the world acquire?

Let's say the bells and whistles cost $1,000 per person, or $10,000 per person, or $100,000 per person over an interesting number of generations. When you multiply that by six billion, or eight billion, or 12 billion, you are running up against the economic realities of how much Cro-Magnon man can change on a truly global scale.

This goes back to the point that we have to consider the world outside the United States.

Perhaps one of the more interesting aspects of what Jon is being confronted with is the question: How will the naturals—those who remain somehow more like today, or those who consciously decide to remain more like today—be different as the new kinds of varieties of people evolve? What will be the interaction among them? What will be the different value sets among them? We can talk about the value sets today in Cro-Magnon man. Every Cro-Magnon man today seems to want a cell telephone. I don't think they wanted that 10,000 years ago. But what are the "cell telephones" that the Cro-Magnon people of 40 generations from now will want? We are right back to my tedious, dull point: Jon needs imagery. And we can get to imagery only by being concrete about the kinds of changes.

You talk about sex, and love, and walking around: What is the animal life of Cro-Magnon man going to be? Everything below the neck: How will falling in love be different? I could see using profiling: Instead of having to meet 50 candidates before you find the right one, you could use profiling and have a selection of six or three or two or "this is really the one for you, Jeff." How will love change? How will sex change? Are we going to find that machines are better than people? Maybe for some it will be.

Andreadis: For some, it already is.

Coates: There was a rather obnoxiously prominent article in *Wired* a few years ago called "Teledildonics: Remote Sexuality," and it wasn't making a distinction between remote sexuality with another human being or with a machine. These are the kinds of things we need to be talking about.

Jeffry Stock: That is what the internet is all about.

Coates: No, we're talking about physical encounters remotely. But it seems to me that we are back to the point: Do we want to see this as Cro-Magnon man with bells and whistles, or are we really moving to something that is fundamentally different? I opt for bells and whistles.

We underestimate humans when we say that what they want are cell telephones and leisure… people have burning desires… We are driven…

Campbell: I agree with what you are saying except the idea that these things are bells and whistles. That underestimates their value and meaning. One of the difficulties we have is that the short term can be extrapolated from the present, especially the very short term. But the long term cannot, because the forces for change then have not yet come into being. The only concreteness you can get are discussions of what new forces are going to develop, rather than what they will subsequently lead to. As Greg said, if you do not stick to causes, you can propose any scenario, because the possibilities diverge with time.

We underestimate humans when we say that what they want are cell telephones and leisure. Hey, we are here on a Sunday! I think that people have burning desires … to go into central Africa, to write the All-American Novel, to try to figure out the secrets of the universe. We are driven, and that is embedded in our psyche. The reason people are going to try intensively to manipulate and improve the human being is because they will take that on as a goal, and even a monomania. If we do have significant improvements in humans, they are going to be made by people who are very strongly driven. Those people will be driven by goals, and what the goals will do is give them extra powers.

What we should talk about is not how people will make love in the future or whether they will walk to work. We should think about what possibilities may open up from an increased intellectual capacity that we don't have now. I mentioned yesterday the enigmas of time. Time doesn't make sense. If we were able to comprehend time and to grab it by the tail like we can the genetics of humans, then we might be able to do or understand or build all sorts of novel things. Or mentality: We don't begin to understand mentality—whether dualists, behaviorists, or whatever. If we were able to comprehend and manipulate mentality, it would open up a whole new ballpark for existence. The idea that what we are interested in is fiction about how people are going to run around and mate a thousand years from now misses the point completely.

Palfreman: I wonder if we could pick up on the earlier part of that: this notion of elites and human rights. Do

we think that in the year 3000 we will extend our notion of human rights to include animals? That was another thing that came out yesterday: If you experiment on animals and give them intelligence and other enhancements, would that mean giving them rights, or will we be more divisive, with elites dominating other elites? That is an ethical question we might talk about.

…if you have a new emergent phenomenon, it is not going to be bells and whistles; it is going to be integral to what defines the next stage.

Andreadis: Those two things are not mutually exclusive. First of all, I agree with you that there is one thing that has changed. One variable that has changed is the rate of change. That is going to make things different, because if you have a new emergent phenomenon, it is not going to be bells and whistles; it is going to be integral to what defines the next stage.

On the question of elites, there have always been elites, even if defined by blonde hair versus dark hair. Humans will make distinctions whether they are real or unreal, so the elites will be with us as long as we are human with our primate urges, because that is the way humans and primates tend to organize their clan groups.

Palfreman: John was arguing, though, that some of these subgroups would have much greater influence and power.

Andreadis: They may, but the counterbalancing fact is that we have become more inclusive at this point. I think there will be extension to other … for example, there was, and still is in the Muslim world, an argument about women not having souls, but they are human, because, after all, they produce human children. You can define it any way you like. This is actually a political/cultural/social decision, not a rational decision.

Hughes: If you go back and review the movie *X-Men*, it will probably give you a good picture of how this might play out. Some groups of posthumans will think that posthumanity is an advance and that humanity needs to be left behind. Some groups of humans and posthumans will feel a common identity and try to create a society in which they respect one another in a transhuman set of ethics. And then there will be people like Kass, Fukuyama, and Christian fundamentalists, who are human racists, who think that only the human race should be permitted to exist and will deny any ethical significance to both animals and posthuman developments. All three of those things will exist. One of my passionate concerns is to build that transhuman set of ethics.

Coates: Do you see us moving beyond Cro-Magnon?

Hughes: Absolutely.

Coates: So, you are really seeing a new species.

There will be a variety of different kinds of transformations of posthumanity where people feel a common affinity for one another.

Hughes: I don't like the term *species*, because I don't think it will be a question of breeding. We will be able to breed in a wide variety of ways. Bruce Sterling invented the term *clades* in his *Schismatrix* series. There will be a variety of different kinds of transformations of posthumanity where people feel a common affinity for one another. There will be people who are biologically enhanced; there will be people who are cybernetically enhanced; and those kinds of people, as you said, probably won't have much to do with one another. It is not so much a question of species as of just common affinity.

Gregory Stock: I think there will be large amounts of conflict, and there *will* be the formation of elites in some sense—not just by biological potential or biological capabilities, but the amounts of technology that they have. These two things will be going on at the same time: There will be concentrations that are in conflict in a variety of ways, not necessarily overt military conflict, and then there will be an extension of rights based on the sense of acceptable behavior for other kinds of creatures. It will be a very rich mixture, a difficult mixture to understand. You can see it today where all countries have a vote in the United Nations and there is a sense somewhat of global government, but power is very dominant. The United States is going to go out and do what it says it is going to do. It is moderated in a variety of ways.

Those sorts of issues are going to become increasingly difficult ones as we go into the future. There will be large numbers of peoples and cultures that have very different views of where humanity should be going, and have access to technologies that they themselves did not

develop. You can see that where there is a fight against modernity today. It is going to be very turbulent.

Coates: Over what time period? Over 100 years, 200 years, a thousand years?

Gregory Stock: Over a thousand years. This is not going to stop. I don't believe this will be just a short transitional period. When you say, "Over what period of time?" that question predisposes a burst of development that is somehow going to take us to a new, stable stasis. I don't see that.

Coates: We talked about world government as a factor in stabilizing that state. Are you dismissing the notion of an effective global government over the next millennium? That was the whole point of a global government.

Gregory Stock: I think that there will be a moderation of certain kinds of activity, but that there will not be an effective global government.

The difference between us and other mammals is the fact that we have separated ourselves and made ourselves observers. Then we started tinkering…

Andreadis: I am very glad Joe mentioned the word *Cro-Magnon*, because I want to address that. The answer is: We are and we are not. He made the important distinction of "neck up" and "neck down." From the neck down, there is no question that we are Cro-Magnons; from the neck up, we are not Cro-Magnons anymore. The difference between us and other mammals is the fact that we have separated ourselves and made ourselves observers. Then we started tinkering with what we observed, for our curiosity and pleasure. That, I think, is a qualitative difference between the protohumans and us. It is quite possible that when we first became human, Cro-Magnons, we were not aware of the disjunction between ourselves and nature. We heard noises or voices from the trees; there were animas; everything was imbued with spirit—it came from here, but we did not know that. The voices of the gods came from the heavens.

Now we actually have made a huge difference in how we think, and that is what makes us not Cro-Magnons anymore. It is true that our beliefs, like our religions, are Cro-Magnon. They haven't changed. We believe what farmers, fishermen, and shepherds believed 2,000 years ago. But the parts of us that are different do think differently from the way Cro-Magnons thought.

Coates: Aren't you confusing biology with culture? I think you are confusing genes and memes.

Andreadis: On the contrary, I am telling you that they are separate. No, I am not confusing them.

Coates: The memes have changed, but there is no evidence that the genes have changed.

Andreadis: First of all, I don't like *memes* for a number of reasons. But there is a cultural continuity, and the overlay of it is very strong—strong enough that it is altering the way we behave as biological organisms.

Coates: No question about that.

Andreadis: It is not a question of confusion, but a question of synergy, which is another word I dislike.

Campbell: One problem you have, Joe, is that we have not really started to tinker, or change, or evolve the human being, because we have just found out how to do it. I don't think it is meaningful to say, "Look, we haven't evolved our biological or genetic characteristics in the past, so let's not expect it in the future." The promise for the future is to be able to do that which we haven't done in the past.

The important thing is that if there is a component of humanity, or descendants of humanity, who have developed capacities and abilities to do things that are monumental, they aren't going to be concerned about the rest of humanity that is around them. Yes, we worry about animal rights, but that is not really a big concern.

Palfreman: We worry about humans with disabilities.

The power that comes from science is not under control of the political process.

Campbell: That's right. We worry about humans with disabilities because they are very similar to us. We think: "There but for the grace of God go I." But the promise is that there are going to be advances great enough that some parts of humanity are going to say: "Those trivial beings of the past, those fossil remnants, are not where the action is. The action is to go to the stars, to conquer time, to build ever-increasing capacities for humans." That is what is going to interest them, and these other things are dismissible details.

We talked about world government: I don't think power comes from the political process. It comes from

the scientific process. I was in Australia 40 years ago when the Pill was first coming in. I saw parliamentarians on television ranting and raving that they were not going to let the Pill into Australia, because the government wanted the population to increase and their women had to breed! I looked at those people and thought: "You arrogant fools! You politicians have no control over whether this technology comes in or not. Yes, you may be able to delay things a little bit, but the decision is not yours." The power that comes from science is not under control of the political process. Whether we have a world government or don't have a world government—that is quite irrelevant to what the advancement of our human descendants is going to be.

We are getting the capabilities of controlling life, and that has both a downside and an upside.

Jeffry Stock: It is interesting to think about conflict and the negative side of things. For example: What is war going to be like in the future? You can say that we will not have wars, but if we do have wars, it seems to me that they will be biologically based. So, we could have a completely different situation in terms of disease. It is possible right now to wipe out populations, and the United States has the lead in that area.

I think things are going to go away from silicon and more toward organic. We are getting the capabilities of controlling life, and that has both a downside and an upside. The downside is the worry of terrorists making biological weapons that will wipe out huge parts of our population and disrupt our economy. Then, between individuals: How are individual conflicts going to go, in terms of violence? Right now we are in a very peaceful period. Is that going to continue or not? I am not sure what is going to happen with conflict.

Jhirad: Can you think of past historical situations or periods that are examples of rapid change and how people may have adapted, or not adapted, to rapid change? Those might be stories that could be in this series. One I think of is Jared Diamond's *Guns, Germs, and Steel*, where he looks at the impact of farming on humanity. It set things up for some societies to become dominant over others. Is there some story we might be able to draw on from the past, from archaeology, from anthropology, that could offer an example of how society did or did not adapt to rapid change?

Velamoor: Bill Calvin frequently brings up the point that technology and advancement are proceeding at such a rapid rate that our ability to see the implications is always lagging. That will increase, it seems to me, not decrease. In other words, our headlights don't go far enough ahead to see what is out there.

Gregory Stock: One can see examples of rapid change that combine the notions of biological warfare and possibilities for disease—for example, the Aztecs—where whole cultures have been swept away in an instant. While it may seem very tragic at the time, it is forgotten very quickly and becomes only a memory. What do we think even looking back at the Black Death in Europe? There can be enormous disruptions that occur on a very small timescale that are, largely, just part of the landscape when we look back at it.

Andreadis: That is an interesting question, because generally people feel that first-contact situations are always catastrophic, and they often are. They have been in the past in meetings of humans. But I can think of a few that are quite interesting, for example, the Lords of the Plains: the Lakota and the Crow. Do you know that they didn't have horses before Europeans came? They were hunting buffalo on foot. They took the horse and integrated it into their culture, wherein within one generation a man's status was indicated by the number of horses he could give to his father-in-law. Here is an example of immediate change; they had about one generation to become masters of the horses before the next wave of Europeans came. The reason they were slated for the wrath of the US government was that they had become equals; they had become a threat to be reckoned with. Before, when they were running around on foot with stone spears, they were not a threat.

If social evolution does not proceed in a parallel way to physical or genetic evolution—forced or not—there will result an utter state of chaotic unpredictability.

Zimmerman: If we look at world history up to the present day, we see that every time there was an identity of a group vis-à-vis a different group, that was grounds, essentially, for annihilation. If we look at the instances of genocide within the past ten or 20 years, they are numerous. Whether or not different groups coexist depends very much on the type of governance or society in which these encounters take place—and that is far less predictable than the progress of our ability to mod-

ify human beings genetically. We are on much safer ground when we can look ahead as to the developments in science and technology. What we can't predict is the chaotic behavior of national governments and global politics, and so much of the survival, or not, of an individual group is going to depend on the status of that. Here is where we are in big trouble in terms of trying to look ahead.

During the 1980s, I had occasion to spend time in Serbia, where there were essentially three ethnic groups apparently coexisting peacefully, getting along living next door to each other. The regime at the time was an oppressive, joyless, heavy-handed communist regime that everybody hated. When that went away, we saw what happened in the early '90s with the conflicts in Bosnia, where the people who had been peacefully coexisting, as soon as the lid came off and the constraints weakened, were raping and murdering their neighbors. This reflects some embedded qualities in human nature.

I can't imagine that it would be that different if there were, say, subpopulations of human beings that were genetically enhanced and superior. Maybe for a time in a given society they could coexist, but as soon as there is a perception of fear or competition or threat, then everything depends on the social structure in which these exist. That has to be acknowledged in this series. If social evolution does not proceed in a parallel way to physical or genetic evolution—forced or not—there will result an utter state of chaotic unpredictability.

Palfreman: You could do this in either of two ways. The insights of evolutionary psychology would tell us that we would expect people to react in very antisocial ways if they are put into certain situations, so our governments and institutions would try to prevent that. Or, we could try to do it through genetic enhancements on the limbic system.

Zimmerman: Exactly.

One of the serious motivations for creating a global government will be…prophylactic measures for apocalyptic consequences of new technologies.

Hughes: That is a good point. About world government: One of the limits of conceivable governance is the planetary basis of it. I believe world government is inevitable within the next couple of hundred years, but I don't think a solar government is very conceivable, and I certainly don't think an interstellar government is very conceivable. We will be well on the way to having interstellar colonization, and so there will be political diversity. One of the serious motivations for creating a global government will be anticipating, preventing, and prophylactic measures for apocalyptic consequences of new technologies.

One of the technologies we have not addressed much here is nanotechnology. To return to something French projected for the next 25 years: We are going to have artificial organs of many different varieties. So, going back to the question about Cro-Magnons above and below the neck, what exactly does it mean that we will still be Cro-Magnons if we have artificial liver, artificial kidney, artificial heart, artificial lungs, artificial blood? We could have "respirocytes" in 25 years; Bob Freitas has the patent for that. It would allow us to have ten times the amount of oxygen-storage capacity in our blood. If you had a heart attack, you would say: "My God, my heart just stopped beating," and then you would walk to the hospital and say, "My heart stopped beating and I really need to do something about it." That is a very different nature of a human being below the neck within the next 25 years. I think the question of whether we are still Cro-Magnon when we have that level of invasiveness of technology inside our bodies is profound.

I don't think we are in a period of as rapid change as we have been over most of the last thousand years…

Jeffry Stock: I disagree with a couple of things. One: I don't think we are in a period of as rapid change as we have been over most of the last thousand years, if you really look at it. I think we are entering a period, actually, of stasis. We are tweaking our technology. We have a telephone; now we have a cellphone. We have television—actually I think television is degrading in terms of quality. It is becoming like radio. Radio was the big thing in my father's generation, and everybody sat around and listened to the radio until it became too broadband—too much information. Now it is background. Television was really big when I was young, and now it is becoming very broadband—too much information. A lot of what you have been talking about has to do with IP [intellectual property] and technology companies hyping their products.

Actually I think we will be lucky in the next 25 to 50 years to cure a lot of diseases. We could have new dis-

eases; infectious diseases will be coming back. There are all kinds of problems. We *are* going to die. If we live another 100 years extra, we are still going to die. What is going to change?

What *has* changed is that we have had this incredible period of human population growth and we are reaching the end of it. Something like five percent growth every year is necessary for our economy. Look at Japan. Are we going to continue to increase our population? That will work only for a certain period of time, and then, what is going to happen? I don't see that we are going to continue at this pace.

Coates: I wonder if it would be valuable for Jon if we tried to do something in two parts: First, identify some themes for him that should inform his third part, and then perhaps deal with the themes more specifically. One of the themes I think we have some agreement on is that there is going to be something between variation and speciation among people. A second theme we have hit on is that there will be global government, whether it is a partial or a total success.

Another theme implicit in what we have been talking about is that most of the human diseases and disorders, and a large amount of the human improvement will already be history—it will be taken care of—so that what will happen in these centuries leading up to the year 3000 will be much more by way of human enhancement. I think another theme is that information technology will not only be ubiquitous, but that it will directly interact with the human organism. How, when, and so on are questions of specifics.

If we could identify more of these themes, we will give Jon a kind of Christmas tree on which to hang the more specific things he needs. One that may not be consensus here is that we will fundamentally be Cro-Magnon with augmentations. That may not be our general agreement, but it may be.

Jeffry Stock: Nobody has disagreed that the majority of humans are going to be genetically very similar to what they are now. You cannot change the gene pool that quickly. I don't think anybody disagrees with that.

Coates: Athena ought to disagree with that, because she was talking about Cro-Magnon then and now. Wasn't it her point that as we move everybody up to a new level of enhancement, we may not change the gene pool, but we will change the quality of each of our genomes? That is going to be a fundamental change in the interaction among people.

Jeffry Stock: The mass is too great. Unless you reduce the population way, way down—which would change everything—you can't take a huge gene pool the way we have it now and do anything. It has a momentum that you can't alter.

Coates: I made that point earlier yesterday, but you are the one who said later that we might drop to as few as 100 million or a couple of billion. Do we have a thematic consensus on that?

Walter Kistler: It is still too many.

Gregory Stock: I don't think there is anybody who disagrees with that, in terms of the vast majority of humanity.

Hughes: You don't think somatic gene therapy will be extant in 40 generations?

Gregory Stock: If there is somatic gene therapy, it would be directed toward diseases of various sorts, rather than toward fundamental enhancements. I think that is beyond the purview of somatic therapy. Would you agree, French?

Anderson: Yes.

Gregory Stock: There is a potential, certainly, for interventions that are more pharmacological or genetic—somatic interventions, perhaps—that might assist in an additional amount of longevity.

Palfreman: Are you saying that in a thousand years, reproduction for most people is still going to be the same as now? If we can get access to *in vitro*, then you can make interventions—right? So, you are implying that most people will still have sex for reproduction?

Gregory Stock: You would have to change the dynamics of that.

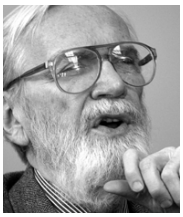
Coates: He just gave you another theme: longevity.

Palfreman: In regard to these themes, what sort of struggles will people have in the year 3000? Longevity interests me for that reason.

…you need to have essentially an immune system where you can get rid of little cancers… that involves various levels of cell recognition and monitoring.

Gregory Stock: Global government has come up a number of times. If you are putting tools in the hands of individuals—tools that are extremely destructive, and you can look at that in terms of biological weaponry or other kinds of disruptive potentials—you need to then exert levels of control over those individuals that are beyond the levels that exist today, because the potentials for destruction are so much greater.

If you think about that in the evolution of an organism—that is, a superorganism of the human grouping that has now come together—you need to have essentially an immune system where you can get rid of little cancers and little problems that arise, and that involves various levels of cell recognition and monitoring. That is what happens within an organism if it is going to continue to be functioning and healthy. This notion of global government steering things generally, versus all sorts of monitoring (and we can already see it beginning) of individual behavior and trying to identify aberrant or dangerous behavior at early stages and address it … I don't know if it fits in this series.



How will we deal, in a democratic world, with these questions of organization, of observation, of surveillance, of safety and security?

Coates: What you are talking about has no relevance to the year 3000, but it is intensely relevant to today: the growth of government, the growth of inspections, the growth of data. Why can't you bring to the social side of your thinking the same drama and change that you bring to the biological side? Why not look at the question: How will we deal, in a democratic world, with these questions of organization, of observation, of surveillance, of safety and security? Why not take as dramatic a look positively at that as you have at the biology? Instead, your argument is essentially: We are going to be in the same miserable state we are today with dumb people doing very big things and creating trouble for us. Why don't you be dramatically creative?

Palfreman: He was drawing an analogy between the immune system and social organisms. Can you have a democratic immune system? If you are dealing with something so complex as a world government, how could you do it democratically?

Gregory Stock: I see that as something that is going to emerge and that is very much beyond the few little images you get of it today. We are talking about something that is a very serious way of controlling and regulating.

Coates: But why don't you look at it as a positive instrument, rather than being potentially oppressive and in itself dangerous?

Gregory Stock: I didn't say that.

Coates: You said 20 minutes ago that global government would be only partially successful and that we will still have conflict and war and violence. Why is that going to persist for the next 40 generations? Why not look positively at how, in the framework of global government, we won't have those pathologies that you are imputing to it? Why don't we look at, in 40 generations, how global government will in fact be democratic, how in fact it will deal with violence universally, how in fact it will reflect benefits for humankind, how in fact it will distribute to those people who are normally left out? There is nothing that says you can't be positive. We can only extrapolate from the present.

Gregory Stock: You are the first person who has accused me of being overly negative about the future.

Velamoor: Those are two opposites that might be something to go forward with: One is the optimistic and the other is pessimistic.

Palfreman: The European community is the model, if there is one, for world government. It is intensely bureaucratic; it has achieved a few things; the amount of red tape is unbelievable. You could imagine a bigger version of that with all the different languages.

Coates: That is like saying that French's pediatric ward is the model for the year 3000 of how children will be cared for. It is a totally outrageous anachronism.

Campbell: This theme of optimism versus pessimism might be an important one for this show, because that will be on people's minds: Are we going toward utopia or down to dystopia?

Palfreman: And that is coming out of everybody's individual psychology at the moment.

The history with all large governments is that they tend to step on individuals; they don't tend to be very positive entities.

Jeffry Stock: Greg wrote a book a few years ago called *Metaman*, and it was very positive in its view of things: Everything is integrated into a global superorganism. I read the book and I didn't think it was necessarily positive, because Metaman isn't necessarily going to fulfill *our* needs. Metaman has a life of its own. I think world government would likely be like that. I can imagine myself in this idyllic little state, running through the Elysian Fields, and the world government could very likely wipe me out. The history with all large governments is that they tend to step on individuals; they don't tend to be very positive entities. Maybe they regulate everything and it all turns out better in terms of the overall economic system, but they tend to step on individuals. If we go into Iraq—we're a world government—we are likely to kill a lot of innocent people.

The battles on high, the forces that involve global regulation of the whole planet, are not necessarily going to be healthy, and we certainly won't be able to control it, as individuals.

Velamoor: In the Foundation video, we heard Howard Wiarda point out that as the size and extent of government increase, that is largely directly proportional to the ungovernabilities that we are reaching too.

…we would have to have some kind of world order…the alternative is to have utter chaos and disintegration.

Zimmerman: Reflections on supernational governments: I have had a fair amount of experience as a consultant for the United Nations—enough to realize how thoroughly corrupt an organization it is. It is unbelievable. It is amazing that it works at all. There is hope for it, but there has to be a lot of change.

I have lived in an EU country, and, yes, it is a step up from that. It is not yet a government. The individual nations retain their sovereignty and autonomy. There are a few common things, and maybe this is a step on the path to something more. It is also ponderously bureaucratic and frustratingly mindless in a lot of things such as the support of scientific research, for example. But, yes, it is something that we should not jettison quite yet. It really needs to be refined and maybe it is a model.

My point yesterday in saying, in response to Joe's questions, that we would have to have some kind of world order or world government, was to say that the alternative is to have utter chaos and disintegration. In order to hold things together, based on my pessimistic view of the way we are going now, with overpopulation and degradation of the environment, we will have to have something like this to keep it under control, or we will not last a thousand years.

Andreadis: The United States likes to think it is the first multicultural empire, but in fact the Roman Empire was multicultural; the Byzantine Empire was multicultural; the Ottoman Empire was multicultural; the Aztec Empire was probably multicultural, although their neighbors hated them. The bottom line is, I think, that the way multiculturalism has worked is by controlled chaos. The Soviet Union was an exception to the rule in being heavy-handed. Basically, there is a huge amount of autonomy, even if you have global government.

Now, if we go to the model—which is, frankly, not pessimistic—that civilizations *will* go to the model of having some kind of global overseeing of activities and the population will shrink to some million, you still have to have a horizon for diversity. Before, you went to the New World or you went to Australia and fought both kangaroos and aborigines; now you cannot do that anymore. We are back to the concept that groups that want to do something different may have to leave this place.

Gregory Stock: It is very interesting to me that we have slowly progressed into a discussion of politics and governance. We were led there by the idea of diversity and the inherent conflicts that might arise—and the level of passion has risen as we have started talking about those things. But it feels to me that we have gone astray from what future humans will be like, what our sense of self will be like, what that diversity will be like, to a discussion of what the consequences will be and how it will impact the shape of our interactions with one another and of our society.

Andreadis: But the problem is that you cannot tease these things apart neatly, because each has an impact on the others. You cannot say that we are going to be good citizens and, to make Jon happy, we will discuss only the biological part. With us, the biology is connected to cul-

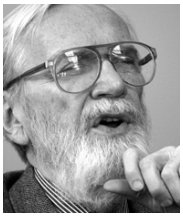
ture, which is connected to politics, and so on. I think it is permissible to stray into the domains of the other episodes, because it is inevitable.

Palfreman: You would be led, through your greater understanding of the human condition and the understanding of its propensity for conflict, to do something about it, either biologically or socially. It would be inevitable. But Athena's point is interesting: You can't take away the wandering urge to move to another country. That has to be allowed.

Andreadis: It has to be allowed; otherwise, we will get sick and die.

Coates: You are caught in an anachronism. You are generalizing the experience of the last 200 years, and it doesn't fit the next thousand—or, at least, there is no reason to believe that it will fit the next thousand. You are saying that we are going to have the same kinds of problems, and we are going to have the same kinds of solutions: "I don't like where I live; I'm going to move." We need to concentrate on what the *new* problems will be and how *they* will be dealt with. If we establish some kind of stability throughout the world, that stability would imply that the problems of Nepal, and the problems of Rwanda, and the problems of this, that, and the other country, will no longer exist as primary global factors. Therefore, the solution you are proposing becomes effectively irrelevant. There is no problem for that solution.

Palfreman: Is everybody happy where they are living in the future?



We need to concentrate on what the new problems will be, rather than patch today's problems onto a thousand-year future.

Coates: Well, they don't have to be happy, but why not look at a more watered-down concept, which doesn't exist today in the world: universal contentment? We don't have to be happy, jolly, smiling, laughing every minute. A very satisfactory goal for the year 3000 would be universal contentment.

The question I would raise is: What are the social issues that are going to arise in the year 3000, or between now and 3000, that are going to call for interesting solutions? One of them is going to be the question of the growth of the variations: How will these variations affect us? The notion of them confined to only one dimension—"My power is greater than your power; I'm going to govern over you, because my group of people have become more important"—is, again, anachronistic. If we were going to move in that direction and we have hundreds of years to make this a reality, what would be the social response? Kill off that genetic variation!

If we see that we have a group of people—50, 100, 300—who are incipient fascists out to rule the world, we will just stop them from reproducing. Why? Because we would have an awareness of what they were thinking, an awareness of what their goals were, an awareness of how they would be different. We need to concentrate on what the *new* problems will be, rather than patch today's problems onto a thousand-year future.

I think you can have universal contentment; it is quite possible that you will, and some of it may be genetically created…

Andreadis: Whether it is anachronistic or not is beside the point. I would argue that the problems will be even more acute if we do have contentment. I am not saying that people will leave if they say, "I am not happy with what I am told to do or not to do." You are conflating what will happen to the average person, or the large number of humanity, versus what happens to the group of malcontents that has always been around and will always be around—the ones who say, "What is over that hill? It may be the same, but it may be different. I am going!"

I think you *can* have universal contentment; it is quite possible that you will, and some of it may be genetically created: They put contentment genes in, and you are content. But some people will say: "The more content I am, the worse it is for me, and I want to go."

Gregory Stock: I think that universal contentment is one of the least likely things to occur, unless it is imposed through a regime of drugs of some sort. The idea of putting genes in or imposing this on the population …

Andreadis: Coersive, absolutely.

Gregory Stock: … is very unlikely to occur. If there are elements of control, it is likely to come from those who are not contented, who are struggling or pushing. For a lot of those people, contentment is really not the object. It is a much more complex thing.

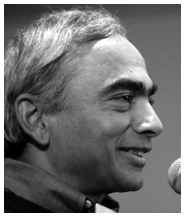
Coates: Greg, remember the social context. When you talk about something being universal, you never mean down to every single human being. Suppose it is 99 percent.

Gregory Stock: I still think it is not going to happen.

Coates: We will always have some discontented people, but in a society in which the overwhelming number of people are content, it is an entirely different situation from a Serbia or a China or an India or a Rwanda, where 20, 30, 40, or 50 percent of the population is discontented.

Gregory Stock: The idea of contentment is a very difficult one to imagine being projected. It is very unlikely that we will be content. If you were to look at the way we live today, you would say that given all the externals, we should be very contented. But we are, by and large, a very discontented society—far more discontented than in other regions.

Jeffry Stock: An interesting aspect of this is the aspect of labor. One of the fundamental changes we have talked about is based on the assumption that there is going to be a lot of leisure time. There is a whole history in human existence of forcing people to work. That seems to me to be the bottom line of not being content. Nowadays in the United States, for instance, we work very hard. That seems to be the way our economy works. There are lots of pressures to consume at a rapid rate and labor at a rapid rate, so the treadmill we are on is very real and that produces a lack of contentment. The lack of contentment is produced by the culture that keeps us working very hard. So, if we don't have to work very hard in the future, there is no reason we shouldn't be perfectly content.



…if you are implying that having everything that technology provides for us is equivalent to contentment …I think there is an inverse correlation.

Velamoor: I don't know, Joe, if you are implying that having everything that technology provides for us is equivalent to contentment, and then to point out 20, 30, 40 percent of Indians as discontented—actually, I think there is an inverse correlation. In this country, there are more people who have more of everything than almost anyone else on the planet, but if you examine the self-improvement and self-help business in this country, it is probably greater than for all the other planetary inhabitants put together—and by a big multiple. So, I don't know what you mean by contentment.

Coates: The percentage of people who report themselves as happy (which is to say, beyond contentment) is virtually independent of the culture and the society. All around the world there is the same fraction that reports themselves as happy. The nature of being happy, contented, discontented, hostile, dissatisfied, has a biological component to it. One of the elements that will clearly come out of this process of improvement is to deal with the people who are constitutionally negative, who are constitutionally discontented. That is not to say that there are not real problems in the world.

Velamoor: Let's give observers around the room an opportunity to ask questions or comment.

Rich Henry, Observer: I think that the power of culture to override biology is absolutely critical, so this notion of global order is going to be critical if we are going to be here in a thousand years. Global order is very different from global control. Greg talked about the metaphor of a global immune system, and I think that is a powerful thing to explore. It is very different from global governance. And the immune system can deal with unknowns that come into it. That is a powerful idea.

The other thing is: I like the theme of optimism and pessimism. Einstein once said that really the most important question is whether the universe is a friendly place or not. It seems to me that for the era we are moving into, whether the *planet* is a friendly place or not is going to be our choice—and that is the choice we have to make.

Stephanie Hilbert, Observer: I am fascinated by this discussion. Thank you very much for allowing me to be here. I deal in a field that examines constantly what it means to be human, and that is theatre and the arts. We deal in controlled chaos, because that is the nature of the arts and theatre.

In many ways I feel that all will be revealed in the third act, and we may be looking at a ten-act play. It is interesting to speculate. If I were staging this, we might have a group of pre-Neanderthals having the same conversation: "What will we be like in the future?" And the extensions of the species—imagine the dinosaurs having a similar conversation. I am wondering, in terms of the future, how we can think of where we will be—or *if* we will be—as humanity, without considering the very essence of things that make us human and humane.

You've been talking about show business and Hollywood and the arts. I'm sure many of you saw Steven

Spielberg's *A.I. Artificial Intelligence*. The conclusion on that, to many of us who watched it, was that the next group that came were far more humane than the humans that ever existed. I think that without including the process of the arts in your deliberation, you will be losing a great deal of the future.

I will share with you that in the 1960s—Roger Stevens, who was the first chairman of the National Endowment for the Arts and Humanities, told me the story—they did a scientific study that found that by the year 2000, two percent of the population would be able to supply the needs of the other 98 percent. And that 98 percent would have to be kept under constant sedation, which is why we established the National Endowment for the Arts and Humanities. As you can see, that certainly has not quite yet happened. In the realm of what can be imagined and what can actually occur, I think the arts are very important to keep in this deliberation process.

Carol Johnson, Observer: There were two comments I wanted to make. First, I think it is a mistake to ignore science fiction, because I think science fiction is where our society has first dared to vision into the future, dared to imagine what our future could be. It is written both by scientists and by lay people, and to change a society, or to anticipate the future, you have to begin with a vision of it. That vision doesn't necessarily have to be grounded in our understanding of reality today. Steven Spielberg, in *A.I.*, did, in fact, vision a million years into the future. It seems to me that that can be the beginning of possibilities. Athena wrote a book where she took the visions in *Star Trek* and actually looked to see whether they were real or not. It is such a rich foundation of possibilities: Are they real or not?

The second comment is: If you look back a thousand years, to the year 1000, and then compare and contrast it to the year 2000, that extreme of change … I don't think the people in 1000 even conceived of the problems we have today, or the science we have today. I think if you can make that similar of a leap to the year 3000, for me, it is a beginning of how much it can be different.

I see scientists as being the navigators of this starship… not the captain, necessarily, saying where we will go— but the fact that we will go…

Andreadis: This is my early summation, since I have to leave early. The universe is neither friendly nor unfriendly to us. It exists independently of us, but what we have is the ability to understand it. I think it would be a grave abdication of our responsibility if we did not continue to try to understand it. I am a scientist. I see scientists as being the navigators of this starship. That is my image of what a scientist does—not the captain, necessarily, saying where we will go—but the fact that we *will* go out on a journey and we will never sleep. We will keep watching in the ports.

I have certain ideas of what our future descendants will be like. They will probably not be like us, but I am hoping they will share our curiosity, because I think that is what distinguishes us. Some of what I am saying is not new. Deferring to the arts, which is a very human occupation, I want to leave you with something that an ancestor of mine said 2,000 years ago. This is from one of the plays of Aeschylus, and this is what he said: "There is the sea, and who will drain it dry? Precious as silver, inexhaustible, ever new, it blooms the more we reap it. Our lives are based on wealth untold; the gods have seen to that."

Stephanie Hilbert, Observer: Athena's comments triggered another thought for me. In deliberating this and thinking of the ancient Greeks and the theater, I am interested in a theatre for the future. Everything in the theater that has existed until the 20th century existed B.C.—Before Computers. We now have that technology, but what will we have in the next hundred years that will make our concepts totally impossible to imagine? I would love to see what William Shakespeare would say if he were here, or if Leonardo were here, to see what we have today. I don't think it could ever have been even glimpsed upon or imagined at that time.

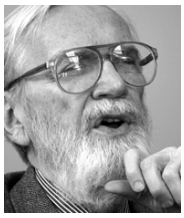
So, here we are projecting a thousand years into the future with new things that can be created so fast. Television was mentioned as being obsolete or boring. This is definitely going to be passé; within another couple of hundred years, we won't have television. We will have holography in our rooms.

…people will explore changes in the human body…not for functional reasons, not to live longer and not to be smarter, but for aesthetic reasons.

Hughes: I want to second that very last comment. One of the things we have underplayed in this discussion is the degree to which people will explore changes in the human body, changes in society—not for functional reasons, not to live longer and not to be smarter, but for aesthetic reasons. We need to think more creatively about that: that people will want to change their bodies simply for the joy of it.

Gregory Stock: You see the earliest phases of that with the "green fluorescent protein bunny" concept, even though it didn't really exist. It was made with an added jellyfish gene.

We had also talked about increased enhancement of animals. Well before these technologies are safe in humans, all the testing process will be in other organisms. Already I get notes from artists who are doing biological art of various sorts. When there becomes a potential to manipulate life in any significant way, it will be at the intersection with art: the effort to create aesthetics, how that will conflict with values about the sacredness of life, where the boundaries are over human control, the sense of playing God. All of these things are going to be fought out on that plane in advance of what is going to happen to us as humans. That will have a very big impact on how we see ourselves too—not just how we see our biology as mutable, but as agents in the world: the notion of being Godlike in some sense and what that implies about us.



If we don't act in a Godlike way, what or who will? When humankind is the measure of all things, the choice is entirely up to us.

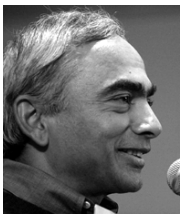
Coates: I fundamentally disagree with this notion that seems implicit in what you are saying: that there are *rights* out there: that there are animal rights; there are other genus rights and so on. I am just an old-fashioned guy who sees that the concept that will come to dominate, because it is the only sensible universal concept, is that *man* is the measure of all things. No rabbits, no cows, no trees, no pansies have any rights of their own. They have only the rights that we impute to them. *We* are the sole measure of all things. When you speak pejoratively of acting in a Godlike way, there is no choice. If we don't act in a Godlike way, what or who will? When humankind is the measure of all things, the choice is entirely up to us.

Velamoor: Let's take a break and come back to hear your summary comments.

Closing Session

In the closing session, each scholar was asked to state his or her vision of the future human. Because Athena Andreadis had to depart from the workshop early, her summary vision statement was given near the end of the previous session .

Facilitator: Sesh Velamoor



…we want to give every participant the opportunity of an uninterrupted soliloquy on the subject at hand: the future human.

Velamoor: In this last session, we want to give every participant the opportunity of an uninterrupted soliloquy on the subject at hand: the future human. Keep in mind that the focal point for this episode is the future human, and not all the other influences that come up. The other episodes that we have in mind for the series do take those things into account. Even though it is difficult to talk about the future human without thinking about those things, please take a shot at doing that, to the extent possible.

Coates: You are talking about the future *animal* called human, right?

Velamoor: Yes, the animal. If you think it is important to embellish with the other influences, then go ahead and do that. A third alternative is to visualize a day in the year 3000 with the future human and all these other considerations taken into account. Who wants to go first? Walter?

…we can fairly predict that one thousand years from now, we will be just like we are now. I don't think we will be a bit different.

Walter Kistler: I have a very simple statement, very simple and obvious, at least to me. Two thousand or two and a half thousand years ago, the Greeks were the most prominent civilization, and they provided the basis of our science and medicine, and even our political arrangements. All of that was invented or created there two thousand years ago, so I doubt that we can say that we evolved or became more intelligent. I don't think we would be able to do such an enormous creative job as they did. So, in two and a half thousand years, people did not change, in my view. I think it is obvious that the Romans were certainly no dumber than we are today, especially when you look at the average of the population.

In a business, it is important to predict what the sales will be of a given product you make. I found that the safest way to draw the prediction curves for the future was to just continue, smoothly, maybe slowly turn up or down, but continue in the same way. As we heard, the Cro-Magnon genome did not change very much in 40,000 years, and certainly our brains did not change very much in two and a half thousand years. So, we can fairly predict that one thousand years from now, we will be just like we are now. I don't think we will be a bit different.

…most of us will look more Chinese than we do now—that is the largest gene pool—and maybe darker, because of the Indian subcontinent.

Jeffry Stock: I agree with that. There is going to be a big change, though, over the next thousand years. The major force is going to be that population isn't going to continue to grow globally the way it has. That is a difference, and that is going to cause a slowing down in some of the changes we have seen in the last 500 years, with the movement of the West into the New World, which has caused dramatic changes since the Greeks.

I think most of us will look more Chinese than we do now—that is the largest gene pool—and maybe darker, because of the Indian subcontinent. Those make up the largest number of genes, and there seems to be a mixing globally in the gene pool.

In terms of language, there are educational advances that we haven't touched on that come out of computing. I think people will be able to acquire new languages much more readily than they used to, through advances of understanding how people acquire languages, and the use of the interactions of people with computers or more advanced instruments. That will open up a huge amount of art to everyone, when we can start to access other languages and other art forms that exist now.

In terms of the "neck up" and "neck down" questions, I think the "neck down" is much more important than the "neck up." I think we will be very concerned about our health and that our health will get a lot better and we will live longer—though I don't think it will seem as important, once we do live longer, than it seems right now—maybe even up to 200 years in the maximum life span.

In terms of love, sex, family, and issues of reproduction, which are the most questionable as to what is going to happen, the most likely changes are what has already happened: We have divorced reproduction from sex, and we will deal with sexually transmitted diseases. The family will change a lot, and people will have sex a lot more, with a lot more different partners; it will be more hedonistic than we are now. I think we used to be a lot more hedonistic than we are now.

In terms of war, because of the longer life, we will be concerned (as we are starting to be now) with safety. I don't think there will be a lot of war. There probably will be some global government, but I don't think it will be of much concern to individuals. It will be just for organizing the planet and keeping things under control.

In terms of what people want to do, there will be a lot of game-playing, a lot of art, a lot of storytelling, and maybe in some way we will get back to the ability of people to perform for each other, rather than going to all these outside sources. That is maybe too optimistic. I think people will learn, with their leisure time, to play, to sing to each other, to tell each other stories, and maybe that will come back. Optimistically, I would like to see us, in some ways, go back to the future, to achieve some of those idyllic states that we imagine for the small numbers of people who used to live in Greece (not the slaves).

…there is a fairly low probability…even if a highly superior human or transhuman can be created, that this would displace or replace Homo sapiens…

Zimmerman: There are a lot of ways to look at this. Our starting point is a current population where the human race is all of the same species, in that we can all interbreed with each other. But there is a great variety of differences, lying in about 0.1 percent of the genome apparently. There may be many SNPs [single nucleotide polymorphisms] as well as more complex allelic differences that are critical: certainly in talents and abilities of all sorts, so-called intelligence, musical ability, artistic ability, creativity, memory, but also there are differences in personalities. Some people are kinder than others; some are more aggressive; some are more altruistic. This is an area of the more primitive brain. Usually we think of intelligence in terms of the fact that we have the capacity for scientific inquiry and the creation of technology, and there would be a desire to improve upon these abilities, but what about other behavioral characteristics? If we are thinking about modifying and redesigning people, shouldn't we look at these traits as well?

To a first approximation, there are two kinds of people: There are the risk-takers, the adventurers, the explorers, those who are excited by the unknown. Then there are those for whom change is frightening and who need security. We see this in our current populations. I would say that most of the people in this room are of the first type; it is a selective group. But this has to be taken into account in how any new attempts to direct the evolution of the human species are going to fare.

I brought up the question: What happens when a minority subgroup or subspecies in the next 100 or 200 years interacts with a much larger society of so-called unchanged? I suggested that there would be fear of such groups, as we now worry about too many aliens; this is a problem that is never-ending. There is the whole question of global governance that has to interface with whatever we consider to be a desirable change in evolution, and governance at all scales is intrinsically chaotic; it is unpredictable. Perhaps to a limited extent, developments in science and technology can be foreseen, although even there we have to be prepared for new events and the unexpected breakthroughs that we can't anticipate now. In other aspects of human existence, the system is utterly unpredictable. If the uncertainty that pervades everything is not taken into account, we are going to delude ourselves with respect to the probability of achieving some utopian vision.

What I see us coming to is this: Overall, I would anticipate relatively little evolution in the human species in one thousand years. That is, after all, a very short time in Darwinian terms. I guess I would agree that our capacity to make modified people certainly will exist from a technological point of view. We *will* understand the relationship between genetic structure and function to the point where we *can* do directed genetic modification. But this is only a small part of the story. Whether anything we do or the products of this kind of intervention will survive and have a survival advantage in a Darwinian sense, so they can propagate and proliferate, is another question altogether, but certainly one that has to be taken into account in trying to see where the human race will be in one thousand years.

I would say that there is a fairly low probability, even starting now, even if a highly superior human or transhuman can be created, that this would displace or replace *Homo sapiens*, Cro-Magnon man, in one thousand years. It *is* possible. However, I am a bit dubious that it will happen, given the high degree of uncertainty in all sorts of global systems that are going to have to be taken into account to make these kinds of projections.

An informed society is the only chance we have that the enormously powerful abilities of the technologies we are developing will not be misused…

Anderson: I agree essentially with what Burke said, and I will basically repeat what I said before: In a thousand years the human species will be bigger, stronger, faster, smarter, and so on. We will have the technical ability to do those sorts of things, but what is critical to my mind is whether we have the wisdom to do it in a way that does, in fact, benefit humanity as a whole. What to me is most important is not: Will we have made the technical advances?—I think we will have—but how those technical advances are used. My feeling is now, and has been for a number of decades, that the only protection our society has from itself is to be informed, to be educated. An informed society is the only chance we have that the enormously powerful abilities of the technologies we are developing will not be misused to the point that humanity suffers from the technology, rather than benefits.

I am basically an optimist; I think society will use the technological advances for benefit. I have to say, even though it is "taking coals to Newcastle" here, that this Foundation For the Future is precisely the type of organization that is really critical, because what it asks is: Where is humanity going? The Foundation hopes to educate and help humanity go wherever it is going in a wiser way. I think meetings like this are critically important. It is the hope for the future that people think *now* about what is going to take place over the next 50, 100, 200, 500, one thousand years. It is our best hope that we will make use of technology in a beneficial way.

We will control the brain, the body, and we will be able to edit our desires, our memories, perhaps our gender, relatively painlessly…

Hughes: If we can keep from destroying ourselves—we always have to have that caveat, and I think that the potential for destroying ourselves, or being destroyed, increases exponentially, as with all these powers—after about 250 years, we will have conquered aging, disease, and the worst forms of poverty. Work will be optional.

We will be repairing the Earth's shattered ecosystem, and we will be well on the way to settling and colonizing Mars, Europa, and other planets in the system. We will control the brain, the body, and we will be able to edit our desires, our memories, perhaps our gender, relatively painlessly—more painlessly than now. And we may be well on the way to preserving personal continuity with these electronic means I have been talking about. That leaves the next 750 years for the really interesting developments.

By the year 3000, the descendants of the human race will be colonizing a widening sphere around this solar system, 400 to 500 light-years around it. The bulk of intelligence at that point will have migrated beyond what we understand as organic, perhaps to something called "molecular computing." There will, however, be a widening variety of organic life, I believe, not only on Earth but throughout this widening sphere in space. One of the challenges for that period will be how this widening galactic social ecology will build a cultural and political system where the powerful respect and treat the weak well. That is the same struggle that we have today. As a consequence of that, well before a thousand years, we will have global governance—and maybe even in a thousand years we might have national health insurance in the United States.

At the point at which individuals begin to share their memories…in a direct, high-bandwidth way, that begins to call into question: What is an individual?

This period raises the most profound challenge to the values I hold most dear: democratic life, democratic respect for individuals, equality and liberty of individuals. The reason is that we will get to a point where the concept of the individual becomes problematic. At the point at which individuals begin to share their memories, their thoughts, their feelings, in a direct, high-bandwidth way, that begins to call into question: What is an individual? And individuals will also begin to share themselves across a variety of platforms—computing, organic platforms—and the question becomes something like: Does the Borg get one vote or a million? (The Borg is the *Star Trek* idea of a collective entity).

There is the possibility of conflicts of that sort, where we need collective decision-making, where we have conflicts between powerful subgroups and less powerful subgroups. Although we will probably get rid of death by the year 3000, we definitely will not get rid of taxes. We will still need to have government, and we will still need to have some kind of collective decision-making.

As for sex, probably the sharing of body fluids will be far less important at that point than the sharing of our minds directly, our most intimate selves. I can imagine the current conflicts between men and women being exasperated in the future. Where now men aren't sharing or communicating enough, then it will be that they don't allow access to that hard drive within their heads. It will be: "What's in *there*? I want to know what is in *there*!" That will be the level of intimacy to which people will aspire: the full sharing of your hard-drive directory.

…inheritance will become of critical importance as families develop and cultivate unique gene lines that are guarded as family secrets.

Fowler: The time periods we have been considering in this workshop (one generation, ten generations, 40 generations) are good ones. I see that the thread that runs between these temporalities is germline interventions. These will be available and will be used, which is the platform on which my vision of future humans is based. Superimposed on that are the natural tendencies of human nature, which I don't see changing in any future that I can imagine.

In that context, I have put a couple of vision statements together, starting with the ten-generations vision. What I heard today from people here resonated with me, and the scenario I have been thinking through for a couple of days and even before this workshop seems to fit. This is the way it goes:

At 250 years, building on the natural tendency to own things, future humans will use the ample intellectual property laws to protect family-specific genetic identities. As a result family values will take on new meaning, and inheritance will become of critical importance as families develop and cultivate unique gene lines that are guarded as family secrets. There will be a major shift in the political system from the individual to the family, with representative democracies being tailored to serve the powerful and the elite. As we have heard from Burke, who has constantly brought up the issue of conflict as inherent to humans and will most certainly continue in the future, wars at that time will be futile in nature, and different geographic regions of the world

will begin to operate more like monarchies. An underclass will remain vulnerable, as it is now, to the excesses of the reigning genetic dynasties.

Scientific racism, which is certainly with us now, will be the ruling doctrine. The attempt to use DNA and genetic markers to widen the social cracks between people will lead, just as it does now, to bias and injustice. In this effort to create a master race of perfectability, of people who are perfect, impediments will be edited out, leading to a reduction in human diversity. That, as Lee Silver says, will ultimately become the gene-rich, who will struggle to maintain control over the natural human composition. But it is always difficult, as we know, in the cyclical nature of human civilizations, to maintain this power, and those with stars on their bellies will be replaced by those without them.

At a thousand years down the road, the future humans will enjoy a world of genetic liberalism, in which, sort of like universal health care, genetic enhancements are enjoyed as a public good.

At a thousand years down the road, the future humans will enjoy a world of genetic liberalism, in which, sort of like universal health care, genetic enhancements are enjoyed as a public good. Packages will be made by a beneficent government—not necessarily a contented one. These packages will be put together of genes of personal choice, like musical ability or financial acuity or increased longevity, but packaged with those will be genes for socially useful attributes, such as altruism. These packages of genes would be regulated by this government—or the power elite, if you will—and available only in these particular combinations. Democracy, then, would be born of necessity, rather than merely a utopian vision, which is what it is now. Accordingly, in this kind of a world, we can take heart in the confidence that future humans will accept the lessons of democracy and interdependence, and will work together to become truly informed and engaged citizens.

The vision of these future humans will become one in which genetic science benefits humankind without compromising individual liberties or discriminating against groups of people. In a future where we go along these lines, polities will have a clear, vested interest in the genetic-policy decisions that affect their survival and the legacy that they leave to their children and, indeed, their very essence.

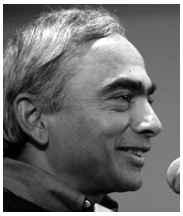
From all of that is going to come, in the best democratic sense, balanced policies that reflect a broad public interest, never mind that *that* democracy of a thousand years is going to be a designed one, but will allow the same elements of choice that are inherent in democracies. But it will be in the context of our reproductive and germline potentials.

Palfreman: What about the genetic diversity problem in the year 3000? Has that gone away?

Fowler: I think humans will continue to reproduce as they do now, and there will be diversity. I don't see that evolution will stop, but I don't think that in that thousand years it is going to produce a different species.

Palfreman: But the package of approved genes won't reduce the diversity?

Fowler: No.



If there are such packages for germline engineering, will there be the option of reversing them?

Velamoor: A question for the experts here: If there are such packages for germline engineering, will there be the option of reversing them? In other words, I temporarily assume a persona and then I say, "Okay, I enjoyed that, but now I don't want that. I want to reverse it and go do something else."

Palfreman: With artificial chromosomes, for example.

Velamoor: Yes. It would create some very interesting possibilities of remaining who we are, and yet seeking out being something different for short periods of time.

Gregory Stock: That would be exceedingly difficult for an individual, because if you do something at the germline—say you chose to be six feet tall, and now you want to be five feet tall. There are going to be decisions that are not reversible for the individual. You might be able to make decisions for your children.

Zimmerman: If it has to do with the development of brain structure from the time one is an infant, that is not going to be easily reversible.

Most of the big changes that I envision occurring are not going to occur from the mechanisms that are available now.

Campbell: Rather than a scenario of what people are going to be like a thousand years from now, the real question is: What is the basis for these predictions? The scenarios we generate can be no better than the bases we have for making them. There are wide varieties of different bases for making these predictions. We have covered some of them, and not others: science fiction, religion, extrapolation from the present to the future, what we might want to eventuate, and such.

The difficulty with extrapolation is that it is basically linear thinking. Most of the big changes that I envision occurring are not going to occur from the mechanisms that are available now. They are going to occur from the mechanisms that will evolve in the future. Since we can't predict these very well, the soundest basis for making predictions is to look for principles of change and see how they ramify when applied to the human condition. There are principles of change; notably, there are principles of evolution.

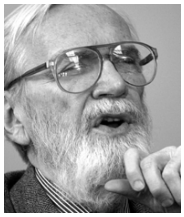
The theory of evolution is not something that has been completed. We are all aware of certain aspects of it, but there are major gaps, especially in the regions that are most important for trying to predict the human future. For example, long-term evolution: What are the cumulative effects of evolution over the long term? That has been ignored. We think of evolutionary theory directed toward what is happening at the instantaneous present, rather than what is going to accumulate from it.

Another concept sadly lacking is that of progress in evolution. If you ask a group of evolutionists whether they believe that evolution leads to progress, they will get very uneasy. First, they are sure to say, "Define your terms," instead of giving an answer. When you say, "No. *You* define the terms," about half will say, "Yes, there is an inherent progress to evolution," and half will say, "No." So, there are these gaps in evolutionary theory left to be filled.

One concept of vital importance to understanding the role of humans in future evolution is the idea that humans are not just the products of evolution; they also are going to be the effectors of evolution. They are going to decide what gene changes to make and then instigate those changes. Their important role will be as causes of evolution instead of products. As I mentioned, the important thing for the future is the development of the agencies that will cause future changes.

…humans are going to change very rapidly and exponentially…there appears to be absolutely no limit at all to the changes that are possible.

Part of the problem is that the principles that govern long-term, evolutionary change are not complete yet for us. But it is clear to me that time is going to go on and on and on, and that we can think of evolution for the next thousand years, million years, or billion years. If you think of these long terms, clearly our descendants—such as they will be—will not have any sort of resemblance to the way we are now. If you just look at evolution over the last billion years, you see how fundamentally different things are. Then the real question is: How fast is change going to occur? How fast are we going to transform our human traits? What one person imagines will happen in a thousand years another will say, "No. That is going to take 100,000 years." I believe that humans are going to change very rapidly and exponentially, on the basis of how fast our genetic knowledge has been increasing and the fact that there appears to be absolutely no limit at all to the changes that are possible.



Three things that I see as essential to understanding the midrange and the longer-range future…are… demographic factors…science and technology…governance…

Coates: Three things that I see as essential to understanding the midrange and the longer-range future and that have to be woven together are, first, demographic factors; secondly, science and technology, because that is the main, overwhelmingly dominant source of innovations in the world; and thirdly, governance or, in the older lingo of the social sciences, "social control." It is a much broader concept than merely government.

In terms of looking at what is going to bring about these changes, in the science and technology area, it is very clear that it is genetics and brain science or brain technology. Of course, the two are linked, but there will be enough differences out of brain technology that we have to consider that as an independent factor.

As the future unfolds over the 40 generations, the advanced nations—the United States, Europe, Japan, perhaps one or two other outliers—will be the place

where the most interesting and most careful developments occur along the genetic line, but other societies may move ahead at a different pace, and one that we might even see to be rashly premature. But it isn't necessary that all of the genetic changes come about through direct intervention in the early phases. For example, in the Washington area, there is an obstetrician who inseminated successfully some 40 women with his own genes. Now, he is a distinctively ugly man—physically, if you look at him, he is a *3* on a scale of 10. The Washington area is going to be populated by these little monsters—"Oh, you're my cousin!" What happens if that same idea is adopted by the premier of China? "Now, in order to satisfy your personal feelings for your own child, we'll use a 50–50 mix on your wife: half of me (premier) and half of you." The crapshoot would work out that we could have hundreds of descendants of these leaders in this kind of centrally dominated society. That would be an interesting thing to happen, because it would give us some clues about what else might occur.

The other thing that is going to come along in the midrange is cloning. Cloning has gotten a bad rap because all the people who speak out against it are ideologues, and the scientific, technical, and other thoughtful community hasn't seen fit to get their oars in the waters; it is too much trouble. But there are a lot of things that could be said for why we would want cloning. But where is it likely to be tested on an interesting scale first? Not in the United States; not in Europe; but perhaps in Korea: a national program to raise the IQ of the nation two points a generation. No great rush; ten generations and now you are an average ten points higher—assuming that genetics tells you how to do this, how to select the people, whether to make a modification in the genes you transfer, and so on. Many of these most dramatic developments are going to occur outside the advanced nations.

Within the advanced-nations context, where the most important developments will occur, it is important to address attention to the social-control issues.

Within the advanced-nations context, where the most important developments will occur, it is important to address attention to the social-control issues. Fundamentally there seems to be some hostility in this room to democracy as an efficacious tool for controlling the big things in society. Now, I have no religion, but if I had one and I could declare it as such, I am a thoroughgoing Jeffersonian: "An informed electorate is the key to a successful society." If we can keep people informed, people are going to come back and say, "This may not be good; this may be good; this trial didn't work; let's not do that again." I have great confidence in democracy to keep the early stages of the next two, three, and four generations of the use of these marvelous technologies constrained in a positive way and promoted in a positive way.

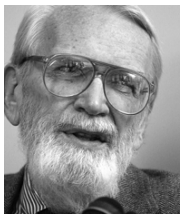
What is going to happen outside the advanced nations is a more open question, but eventually things will converge as we learn.

One of the things we have to look at, in terms of this passion for longevity, which may be only the flip side of the fear of death in an increasingly secular society, is that we could increase our life spans 20 percent without living longer if we just managed sleep. If we cut our eight hours to six hours, we would add 20 percent to our lives. If we cut it even further, we would add even more. So, we have other ways of dealing with longevity without actually living longer. Almost surely, brain science will give us deep clues as to how to manipulate the need of sleep. Recognize that we know almost nothing about why we biologically need to sleep. There are half a dozen theories, but they are theories in the most preliminary way. So, genetics may find a social competitor—not with extending life that way, but "I'll be happy to live 20 percent longer because you modify my sleep."

There seems to be a commitment to religion as a factor in shaping the future, and yet the unequivocal reality is that the advanced nations are becoming more and more secular. I had an audience of 300 people a year ago talking about the future of this kind of subject, and the question of religion came up. I said, "Let's assume, just for convenience of the discussion, that you are predominantly of a Christian tradition. I am going to run a test and you are going to find this unbelievable. Watch. I am going to give you seven core beliefs of Christianity and ask how many of you believe in them, one at a time. How many of you believe in a personal devil, an entity that infects you and causes you to do immoral things? How many of you believe that Christ is the Son of God? How many of you believe in a triune God? How many of you believe in a place of eternal punishment after death? How many of you believe in a place of reward?"

Of the 300 people, the total number who raised their hands at all was no more than 30 people in that room. I am not talking about who raised their hands for *all* of them. Religion in our society is becoming an empty shell. What are the Episcopalians going to do with all their buildings? Are they going to use them for social purposes? What are the Methodists going to do with all

their basements? Convert them into social centers? So, the notion of putting religion in any central role over 40 generations is an incredible anachronism. We need to get away from that kind of anachronistic system.



If we lost half the world's population, we would be on Easy Street, because we would not lose half the world's knowledge.

Another random thought goes back to Jeffry's notion that the world may be far less populated 40 generations from now. There is a fair-to-middling chance that we will have some major events that knock out large percentages of the global population. I am not going to advocate it; I am not going to promote it; I am not going to celebrate it; but the point I will make is: If we lost half the world's population, we would be on Easy Street, because we would not lose half the world's knowledge. We would lose half of the things draining our resources, mucking up our environment, and so on.

What could these events be? There are only two things that could knock us out as a species. One is a very big asteroid hit, and the second one is an all-out nuclear war. Nothing short of those two will knock out humanity in the next 40 generations, no matter what you can conceive of. All we need is a few hundred thousand people—or 10,000 people or 16 million of them—and maybe as an absolute minimum a copy of an ancient, archival document, *The Encyclopedia of Diderot*—and in 150 years we could collapse all of human development into that brief period. We would soon be right back where we were in development.

I am enormously optimistic about the human future, but we have to look at what the consequences would be of some kind of large event: something like the influenza epidemic of 1918, but on a larger scale; something like smallpox released into the society; maybe some villain will figure out how to make Ebola much, much more stable so it can be much more contagious. Those aren't the only possibilities, but we need to think of what might radically reduce the number of people in that intermediate period. If it doesn't happen, other factors will come in, in all likelihood, to reduce global population. You may not realize it, but today, 43 percent of the population of the world live in countries below replacement rate. The big growers are India, China, Indonesia—already big countries, but in some sense they have the possibility of bringing the most dramatically forceful brakes onto their growth. So, maybe Jeffry is right that we will see a peak and then a decline, and that might come sooner than we think.

What I see missing from our general thinking, as a thematic point, is an idea that was dominant 100 to 150 years ago, and we seem to have lost sight of it. That is human progress. I see all the things that lie ahead—particularly in genetics, in relation to the brain, and other things we haven't talked about, material sciences and so on—as fundamentally saying that the human enterprise is going to get better and better and better, by any set of criteria that you entertain. I would like to see introduced into this thinking as a fundamental notion that the world is simply going to get better, that the turbulence of today will be transitional and within 100 to 150 years, the kinds of things that fill the press, fill the weekly magazines, fill the public-interest groups, will in some very literal sense merely be history.

…we will increasingly deal with replaceable, removable, and upgradeable parts of ourselves—but nonetheless important aspects of who we are and how we live.

Gregory Stock: As we are gaining control over matter and advancing our technology on diverse fronts, we are also gaining control over biology and gaining the ability to influence who we are and the other life forms on the planet. This represents a fundamental shift in that life itself is going to become a field of activity and of play for us. It won't all be serious. I mean that in the sense that the processes that drive biology in the future are not going to be completely different from those that drive fashion, that drive the acceptance of various consumer products. They are not going to be as separated from culture and advertising as they are today. That is going to have a very important influence on the way we will use these powers to influence who we are and who our descendants will be.

I see an increasing amount of diversity simply because there is an enormous amount of diversity in our visions of the human future, and in what we desire. That is going to be manifested in a radiation of forms in the human species. This will not create castes precisely, but something analogous to that, where there are localized self-feedback loops of desire and the ability to translate philosophy and attitude into our biology and into aspects of the kinds of technology we embrace. These

are going to bring up profound questions of who we are, what it means to be human, and why we care about other people as well as other types of organisms on the planet.

We can't see ourselves simply as limited to our own individual biological selves, because we have interactions with large aggregations of technology around us as well. These will become increasingly intimate with us and we will increasingly deal with replaceable, removable, and upgradeable parts of ourselves—but nonetheless important aspects of who we are and how we live.

In addition, as communication becomes easy among people, there are going to be "moving clusters" that have such a deep level of intimacy that they won't feel that they are individuals as much as members of a group. There will be dynamic and changing group identifications, just as there are today people who see themselves as followers of some particular rock star, for example. These kinds of things will not come easily; there will be lots of conflicts associated with them, and some people will see these possibilities as anathema and a loss of values and a loss of our bearings. Others will see it as just wonderful and they would not want to live in any other way.

There will not be "the enhanced" and "the unenhanced"; there will be the categories of the enhanced.

I was thinking about the issue of how many people are going to actually end up being altered biologically in some sense. Actually it is likely to be just about everyone. There won't be any unenhanced individuals, because if there is any value in these developments, if they become easy to do through artificial chromosomes or through genetic interventions that are relatively risk-free, if they protect us from diseases, they are going to spread rather widely. People will say: "Why wouldn't I do that?"—the same way that everybody has a television set or everybody has other forms of technology. At the same time, the differences among us and the diversity will increase, so it won't be uniformity. There will not be "the enhanced" and "the unenhanced"; there will be the categories of the enhanced.

The question is: What are we going to do? That will be driven by echoes of the same desires that influence us now and have informed us in the past. They may be changed in various ways, but those changes—however much control we have over them—are going to be as a result of who we are at the present, so they will be a path of change, which will be strongly influenced by our desires for glory, our inquisitiveness, our desires of affiliation.

They are also going to be strongly affected by what is actually feasible, and we don't know that yet. We don't know what sorts of changes are going to be feasible in the embryo, what sorts of changes are going to be feasible in the adult, what sorts of changes are going to be feasible in electronics and computer technology. There will be a very rich interplay of those things, and we will get a better anchor on those possibilities within the next generation or two.

As to how to proceed on this path, I don't have a clue as to where this will lead us, because all sorts of things that we don't understand today are going to emerge and change our vision. We are very likely to have a smaller population as we head into the future, because there will be big adjustments, either gradual declines in population just because we don't desire to have large numbers of offspring, or catastrophic changes that will happen in the short term.

In any regard, the safest way to move into this is to go forward as quickly and as aggressively as we can in allowing experimentation. It is these experiments that will uncover the dangers that are ahead for us. The more that we artificially ban developments, try to block them and keep them underground, and prevent a free exchange of information about whether things work and what the impacts are, the more we are likely to have large-scale failed experiments. Probably the vast majority of the efforts towards any substantive changes are going to fail and will not be embraced. It will take a lot of experimentation to move ahead. That is the process I see emerging, and it will be a very chaotic and experimental one.

Velamoor: We are reaching the end of the workshop. I would like to thank you all, especially the participants, for coming. It was an absolutely wonderful experience, for the people sitting around the room, to listen to the discussions.

Our emphasis has been "The Future Human" episode, thinking about a thousand years from now, but it is important to keep in mind that we will be upgrading our information every two years. That addresses the difficulty we have been having in terms of asking what will occur 40 generations from now. What we forget is that the 39th generation is what will be used by the 40th generation, so there is relevance in thinking about the immediate past and the immediate future. Even though we may have difficulty thinking about what is going to happen 40 generations from now, most likely the 40th generation will use everything that happened in the

39th generation. Thinking about the year 4000 will be extremely difficult for them, too.

There is great value in this logical incrementalism. Let's not understate the value and importance of doing that. One of the important missions of the Foundation is to update and upgrade continuously, so that the reference for thinking about the future is constantly improving.

I would like to call on Walter to close the proceedings, and thank you again, all, for coming.

Walter Kistler: This was a very interesting meeting with experts in different fields talking, not always agreeing, but at least Jon got lots of input. It will be very difficult now to make everything agree and fit into one picture, but he is expert in doing this.

I would like to thank you all very much for coming. We very much enjoyed the meeting. It is nice for the Foundation to get all your highly capable and knowledgeable brains together. We thank you very much for your input, and we wish you a good return home.

Appendix I

Workshop Agenda

November 8, 2002
Spazzo Mediterranean Grill
Bellevue, WA

- Get-acquainted cocktail reception.

November 9, 2002
Foundation For the Future Offices
Bellevue, WA

- Welcome.

  Walter Kistler
  President

- Introduction to the Foundation For the Future and *The Next Thousand Years* series; Foundation video and Scholar Statement video.

  Bob Citron
  Executive Director

- Self-introductions from all participants.
- Workshop purpose, goals, and process.

  Sesh Velamoor
  Deputy Director, Programs

- Presentation and review of the Preliminary Outline for "The Future Human" program of *The Next Thousand Years* television series.

  Jon Palfreman
  Executive Producer, The Next Thousand Years

- Discussion of Major Issues: Three Plenary Sessions.
- Dinner at Daniel's Broiler.

November 10, 2002
Foundation For the Future Offices

- Summary of Day 1 and agenda for Day 2.

  Sesh Velamoor

- Evaluation of the Preliminary Outline based on Day 1 discussions.
- Concluding session: participants offer statements of their personal visions of the future human.
- Closing remarks.

  Walter Kistler
  Sesh Velamoor

Appendix II

The Next Thousand Years Project Background Notes

"Somehow, everything that humans do and are likely to do into the indefinite future will flow from our self-image. At some point we will agree on what we are collectively as a species, what it means to be human, what is human nature, why we are here, and thence, from all this knowledge garnered and sifted, what we wish to become and what we wish to do."

— **E. O. Wilson**
Pellegrino University Research Professor
Honorary Curator of Entomology
Harvard University

"Advances in science and technology to relieve suffering could dehumanize us."

— **Leon Kass**
Chairman
The President's Council on Bioethics

"But, if nature is always changing, what is natural?"

— **Daniel Botkin**
Author
Discordant Harmonies: A New Ecology for the Twenty-First Century

THE NEXT THOUSAND YEARS TELEVISION SERIES

The Next Thousand Years television series is being developed for national broadcast on the Public Broadcasting Service and will include substantial educational outreach targeted for middle school-aged students. Funds are also being sought from the National Science Foundation, Glaser Foundation, and other private funders. Planning funds will enable the Foundation For the Future to continue research and development of the series as a whole, to develop further a full treatment of one episode, and to prepare an innovative, web-based educational outreach component.

The series examines key humanities debates surrounding the impact of scientific and technological developments on human life in the new millennium. We will explore key intellectual, philosophical, and moral issues that arise in the face of rapid scientific advances in such critical fields as biomedicine, space exploration and travel, and communication and information technology. These involve fundamental and enduring humanities inquiries into the nature of human beings, the nature of human society and culture, and the implications for the relationship between human beings and the physical universe.

The initial concept for the series arose from two seminars and a symposium organized by the Foundation, involving 150 humanities scholars and scientists from 40 intellectual and professional disciplines and 20 countries. The proceedings of these events have been published in bound form and are available for download from the Foundation's website. Because of the success of these conferences, the Foundation For the Future has embarked on an ambitious effort to create a television series for PBS, the internet, international television networks, educational markets, and other venues.

The primary goals of the series are to heighten public interest, foster dialogue, and encourage a better understanding of the potential impact of science and technology on human cultural and biological evolution. The project will explore the moral and ethical issues surrounding choices we might make, discuss our ability and responsibility to manage the future of our species, and help audiences evaluate the risks of unforeseen circumstances that may threaten humanity's survival.

The project will draw on humanities disciplines including history, philosophy and ethics, anthropology, archeology, religion, and such interdisciplinary fields as the history and philosophy of science. The series repre-

sents a significant interweaving of scientific and humanities scholarship and will show how history and biology, the humanities and the sciences, can enrich each other to produce a deeper understanding of the human condition.

OVERVIEW OF THE SUBJECT

Scientists and philosophers, since the days of Aristotle and Plato, have pondered such eternal questions as the nature of reality and the nature of the physical world in a quest to understand human identity and our place in the universe. Today, advances in scientific fields as varied as medicine, genetics and genetic engineering, biology, ecology, nanotechnology, robotics, space exploration, and cosmology continue to push the frontiers of human knowledge. Technology also has fundamentally reshaped patterns of social organization. We have unlocked energy from fossil fuels; developed energy prime movers (electricity generation, internal combustion engines) for human use; created information technologies (computer, fiber optics communication) that allow us to process, share, and store information—to name but three examples. A series of 20th century revolutions have pushed us through a nuclear age, a space age, biomedical revolutions, gene splicing, advances in reproductive technologies, brain research, and a trend toward globalization of commerce and government.

While technological and scientific advances may be drivers of social change, we still have the neural architecture of our cave-dwelling ancestors. We remain influenced by our history, by our culture, and by the potential for seemingly intractable conflicts of the kind that have long plagued human societies. We see today a growing tension between these two forces.

Gregory Stock, Director of the Program on Medicine, Technology, and Society at the University of California (Los Angeles) School of Public Health, sees a "robust future for humanity and its evolutionary offspring, both the biological and nonbiological ones. There is little that can derail the rapid advances now under way," states Dr. Stock, "but the immediate future will be difficult, traumatic, and challenging for vast numbers of humans. We are in the midst of an evolutionary transition as significant as the one 700 million years ago when complex multi-cellular organisms evolved. Future humans will look back on this era (the next few hundred years) as one of the most extraordinary in the history of life, a period when the key developments that have shaped the form and character of their existence—genetic engineering, artificial intelligence and space travel—took place."

To Steven J. Dick, Historian of Science, at the US Naval Observatory, these developments force us to reconsider "our place in the scheme of cosmic evolution" and to adjust "our philosophies, religions, and general worldview to the fact that humanity is not central in space or time." In Dick's view, "The opportunities provided by interplanetary and interstellar travel are the same as those that exploration of the Earth has provided, namely, extension of knowledge, vision, and wisdom."

At times, however, scientific and technological advances seem to outstrip our ability to control them. William Calvin, a theoretical neurophysiologist at the University of Washington, sees change taking place so rapidly, we may be "out-driving our headlights." At the current rate of cultural and technological evolution, "we could wind up participating in changes that could produce big crashes because we don't have time to react. People may go on, but their way of life—their culture and social systems—may be forced to change immeasurably."

Others feel that profound moral and ethical questions are involved. Daniel Callahan, Director of International Programs and Co-Founder of the Hastings Center in Garrison, NY, questions whether "technological progress, particularly in the life sciences, is rushing out of control and violating important moral boundaries. The rapid development of new and increasingly sophisticated biotechnologies has raised difficult questions of values for societies, particularly questions regarding human identity, social relations, use of resources, and our relation to the natural world."

Leon Kass, Professor at the University of Chicago and Chairman of President Bush's Council on Bioethics, has warned of dangers comparable to those seen in Aldous Huxley's 1932 novel, *Brave New World*. In a recent interview for the *Washington Post*, Kass argued: "Advances in reproductive biology such as *in vitro* fertilization can do much. Yet these biotechnologies may also cause us to lose our awe and mystery at the coming into being of a new life. (You can) create a beautiful world where there's no disease, suffering, grief, or despair at the cost of stunted humanity, where these problems are solved, but where human beings lack art, religion, and self-government. The technologies go beyond safety, efficacy, and cost. They change the meaning of what it is to be human. They don't come at once. They come piecemeal. You get used to them without thinking."

Donald Kagen, author of *On the Origins of War*, warns that the scientific advances may delude some into being complacent because they are inspired by the social and medical progress. They may think, he says, that with new technological developments, "future wars

would be too awful for any rational leader or people to embark upon," and conclude that "modern war would be not only futile but also suicidal." He points out that in the past, such beliefs were mistaken. In the years prior to World War I, men like Ivan Bloch, a Polish entrepreneur, and others also felt that the "new realities" would make war impossible, that "the future of war" meant not so much fighting as famine, "not the slaying of men, but the bankruptcy of nations and the breakup of whole social organizations." Yet, wars in the 20th century did take place with all the destructive potential Bloch feared.

Will the speed of change outstrip our ability to adapt? Can the humanities offer us a guide to how we might think about change and remind us how past cultures have dealt with what were for them groundbreaking shifts in the social and intellectual order? *The Next Thousand Years* offers an opportunity to bring together scientists and humanists in stories that explore evolutionary patterns affecting our quality of life and the sustainability of humankind. These stories can integrate humanistic insights as well as scientific knowledge and reasoning based on an empirical approach and the scientific method.

Archaeological perspectives, for example, can provide "the long view," says Clive Gamble, Professor of Archaeology at the University of Southampton, England. "Its record," he says, "contains an ethnographic databank with a five-million-year perspective. We have hardly begun to investigate the implications of that global encyclopaedia from the perspective of collective memory." Jared Diamond, author of the Pulitzer Prize-winning *Guns, Germs, and Steel*, combines history, anthropology, and science to explore why some human societies became more powerful than others. He shows how taking the long view—in his study, 13,000 years—can shed light on hidden patterns in history. He suggests that critical developments in history have often hinged on hidden elements embedded in geography, climate, environment, and the web of life.

Historical, philosophical, religious, and ethical insights enable us to explore issues of values and choices, and to recognize moral and civic obligations. George Cowan, founder of the Santa Fe Institute, debates whether a global ethic is needed and whether "a global ethic can be achieved in a complementary way to existing religions?" Howard Didsbury, Special Projects Director at the World Future Society, asks: "Do we even have a concept of what is good or bad shared universally by all members of the human family when it comes to what may be a threat to survival of the Earth?"

A television series will enable a broad public to explore stories in which these issues are embedded, and to encounter some of the key analyses and debates that have been taking place in a wide range of seminars, conferences, and scholarly works among scientists and humanities scholars. An NEH-supported radio series, *Science and the Search for Meaning*, developed by Sound Vision Productions in 1999, dealt with some of these same issues in seeking to "illuminate profound questions of human identity and our relation to nature as well as to explore the concept of a planetary ethic." Our series will be complementary to the radio series but will cover a much broader range of issues. We expect to target audiences on national television on the Public Broadcasting Service network in a series that features fully developed stories, major international scholars, and world-class documentary film producers.

DESCRIPTION OF THE PROJECT

The television series will cover six one-hour episodes driven by key philosophical and ethical questions about scientific discoveries, human identity, and the relationship of human beings to the physical universe. What is the nature of change? Can we adapt and survive within an environment we have created? What ethics should guide scientific and medical interventions? To what degree should we interfere in the process of aging and death? How has past utopian thought looked to the future? Is there a limit to human potential and a limit to growth?

"The subject of this series, ostensibly, is the far future," says science producer Noel Buckner, who participated in the consultation phase of the series, "but that is not what we are really talking about here. Talking about the distant future allows us to remove ourselves from the crises we are facing to ask the more fundamental questions about what it is to be human and what it is to take responsibility for society, for art, for religion." Producer Larkin McPhee asks: "What kinds of humans do we want to be? How should we go about solving crises? This series is really about humans and human nature *now*. It is about having a vision. Will we have peace? Will we have equality? What will be the health of the planet? What will we look like? This series moves in the direction of establishing visions as the stories of the future."

We anticipate, at this point, that the programs will include on-camera interviews, subjective filming with modified historical re-enactments and pre-enactments, on-location filming, and computer-generated anima-

tions. Our goal is to develop compelling story lines enriched by analyses and competing perspectives. During the planning period, we will work closely with film producers and scholars to interweave elements of story and scholarly and scientific insight.

Executive Producer Jon Palfreman has begun collaboration with series staff: Bob Citron, Executive Director of the Foundation; Kirk Citron, Senior Writer; and Sesh Velamoor, Deputy Director of the Foundation. A number of producers are in the process of being brought on board and have participated in wide-ranging discussions during a workshop and in phone conversations afterwards. At a meeting of scholars and film staff, story ideas were evaluated and developed further. The team reduced the series from eight to six programs. These descend in scale from the evolution of the cosmos to the legacy of the human mind: knowledge. Each episode offers wide-ranging explorations that take the audience both into the far future and into the past. These programs are still in development and will continue to evolve with the insights of our advisors. While each of the six programs will be developed by a different producer, Jon Palfreman and the Board of Advisors will provide continuity for the series as a whole.

THE PROGRAMS

PROGRAM 1: Earth and Beyond
Scale: The Universe

Program Content

The first episode catapults us, as individuals, out of our mortal time and space, and gives us a novel perspective of the solar system. The context for this first episode is the story of our planet. In the past few decades, scientific discoveries by astronomers, physicists, geologists, and biologists are suggesting a new creation story. Their vision of the solar system sits uncomfortably with many current belief systems. As has happened previously in history—from Galileo to Darwin—scientific ideas and discoveries must be accommodated with other systems of ideas with which they apparently conflict.

This new scientific creation story gives an account of how the Earth came to be some 4.5 billion years ago, how life arose, and what will be the likely fate of our planet. According to most scientists, in a few billion years the Earth will meet a fiery end as our star, the Sun, becomes a "red giant." From the perspective of this vast, impersonal narrative, the evolution of human beings and human culture represents a tiny side story—a blink in the eye of the cosmos. Long before this fiery end, the human species remains vulnerable to catastrophic impacts with asteroids and massive climate changes, either natural or man-made. Some 500 million years from now, due to predictable changes in the Sun, the Earth may become uninhabitable—all the water may boil off. What will be our fate? Will we travel to other planets, setting out on enormous, uncertain journeys, much as Polynesians set out to find other lands 2,000 years ago?

We hear a contrasting view from Sir John Polkinghorn, a former physicist turned priest, and from Paul Davies, a physicist who speaks of God and the new physics, in what he calls the *anthropic principle*. "The universe," he says, "wouldn't be there if we couldn't imagine it there."

PROGRAM 2: This Tiny Planet
Scale: The Earth

Program Content

In our second program, we are centered on the Earth and issues of sustainability and survivability. With the population due to double by 2100, we face many environmental challenges. Some see human-planet interactions as threatening the long-term livability of the planet, affecting population, the carrying capacity of the Earth, sustainability, the availability of natural resources, and global warming. Will our political system evolve? Will human society be able to survive anthropogenic disasters from climate change, ecological horrors, starvation, or war? Will humans fundamentally and irrevocably upset "the balance of nature"?

Others challenge a concept of nature and of the planet that implies limits. In their view, new scientific discoveries are fostering a more complex understanding of nature. "If nature is always changing, what is natural?" asks Daniel Botkin, biologist at George Mason University and author of *Discordant Harmonies: A New Ecology for the Twenty-First Century*. "If we want to return a landscape to its natural condition, which of its many conditions should we choose? We should realize," he says, "that … there is no single pristine state of nature … but rather a set of nature's designs. We have a choice of what is natural." He claims that the "balance of nature" idea is unrealistic and contradicted by many observations. "It appeals to us," he says, "because of its strong ties with Western religious traditions; a benevolent, perfect, and all-powerful God could only make a perfect world."

Jonathan Overpeck, Director of the Institute for the Study of Planet Earth, challenges the idea that the

Earth's sustainability is solely affected by human-planet interactions. He asserts: "Climate has been traditionally assumed to be stable and predictable except when disrupted by unusual conditions; but relict sand dunes, tree rings, and other records of past climates show evidence of mega-droughts and other climate surprises over the past 2,000 years."

David Quammen, author of a series of books on nature, agrees somewhat with Overpeck and Botkin: "Even extinction has been a natural force of ecological change." But he cautions: "In recent years, waves of species extinctions have correlated suspiciously with migrations of human populations." Quammen points to the long-term impact of human beings on the Earth. The future, he suggests, could result in the extinction of nonhuman primates. "There will be no wild. Trees (will) still exist, a modest catalogue of species, but parcels of trackless forest (will) not." He calls attention to a major wave of extinctions affecting the large-bodied fauna of North America, South America, and Europe. Even a century ago, Darwin and the naturalist Alfred Russel Wallace noted a pattern of impoverishment. Wallace acknowledged: "We live in a zoologically impoverished world, from which all the hugest, and fiercest, and strangest forms have recently disappeared … a sudden dying out of so many large mammals, over half the land surface of the globe."

We explore the possibilities of biodiversity collapse and pandemics caused by man-made and natural factors. The program reflects on the possible development of safety mechanisms—planetwide preventive mechanisms—through the application of science and technology, and international treaties.

PROGRAM 3: The Evolution of Culture
Scale: Culture

Program Content

"Human culture and scientific invention represent the most potent force—in terms of potential for change at unexampled rapidity—ever unleashed upon the planet. Biological evolution cannot possibly achieve even one percent of the potential speed of human cultural change," said Stephen Jay Gould. Ideas arise in human minds and, with modern communication technologies, can readily jump from mind to mind until hundreds of millions share an idea. These "memes," as they have been called, can be pure entertainment or they can represent political (democracy, communism) or religious (Islam) ideals or calls to action. Under the influence of different memes, humans are capable of acts of great courage and altruism, utter barbarity and depravity, or of spouting simply mindless nonsense.

This program will look at the power of ideas and how different constructs operate on different time spans—from fashion to enduring ethical and religious notions. How will this play out in an increasingly interconnected global culture? We explore ideas like cyber-democracy and the development of global ethics, and inquire into the future of cultural conflict and war.

PROGRAM 4: Work and Play
Scale: The Family

Program Content

If Program 3 looks at what people may think, Program 4 looks at what they may do. In this program, we examine how humans may spend their time a millennium from now. The program examines the future possibilities of work, leisure, play, art, music, sports, games, relationships, and values.

Futurist Joseph Coates states: "In considering the future, there are three dominant threads—science and technology, demography, and governance. By *science and technology*, we mean things like genetics, brain science, materials (nanotechnology or other yet-to-be invented materials that may replace plastics, etc.), energy, and information technology. By *demography*, we mean: What is the distribution of human beings in space and time? By *governance*, we mean: How are those people organized? Do they live in democracies that foster education and human welfare or are people suffering under some kind of despotism? Why is the future so important? It's the only thing we've got. How else can we build consensus and move ahead in a way that allows us to anticipate benefits and obstacles?"

Coates predicts a world "in which many of the troublesome problems have been dealt with, diseases conquered, work hours reduced since the capacity for production is so large that few people have to work. Daily life will focus on games, art, and service to government and society." But others wonder about the impact of such progress on human families.

If almost all future population growth will be in cities and towns, what will this mean for cultures like the Masai, who have depended for survival on East Africa's grasslands? Urban people have a different impact on the world than rural people, says Barbara Boyle Torrey, Executive Director of the Department of Behavioral and Social Sciences at the National Academy of Sciences. How will modern information culture, for example—of computer chips and satellite hookups—impact on Afri-

can traditions such as the African village in Ghana, asks Edward Ayensu, Ghanian scientist and botanist?

What are the foundations necessary for the viability of traditional cultures in a modern world? In Ladakh, a Tibetan mountain town, Helena Norberg-Hodge, Director of the International Society for Ecology and Culture, asserts, "When you are dependent on the Earth under your feet and the community around you for your survival, you experience interdependence as a fact of daily life." In an industrialized world, "we increasingly live at one remove from reality, relying on mediated information, images, and concepts. There is growing awareness of the interconnectedness of all life." She calls attention to the importance of ecological and spiritual values and to living on a human scale. These represent, she says, "a rediscovery of values that have existed for thousands of years—values that recognize our place in the natural order, our indissoluble connection to one another and to the Earth."

PROGRAM 5: The Future Human
Scale: The Individual

Program Content

Throughout all of history, life has been shaped by the natural forces of evolution, that is, by natural selection. Today, we are seeing the beginning of a profound change—a world in which sex for recreation and sex for reproduction become quite separate activities. We are moving toward a world in which parents "design" children rather than leave their fate to a "genetic lottery," a world in which advances in stem cell research and germline engineering enable humans to live many hundreds of years. If this specter plays out over the next thousand years, it will be a profound and troubling change. It means that natural evolution will no longer be in total control. Henceforth, humans will start to self-direct their own evolution. For better or worse, we are gaining the power to redesign ourselves in what has been called "self-directed" or "conscious" evolution.

Leon Kass, head of the Presidential Committee on Bioethics, has a word for what most people feel on hearing such a case: *repugnance*. He feels that the repugnance of ordinary folks contains a folk wisdom that has been lost by scientists and professional ethicists.

As Kass argues: "Biotechnologies are providing powers to intervene in human bodies and minds that go beyond the traditional goals of healing the sick, to threaten fundamental changes in human nature and the meaning of humanity. These technological changes have brought us to a crucial fork in the road. We are compelled to decide nothing less than whether human procreation is going to remain human, whether children are going to be made to order, rather than be begotten, and whether we wish to say *yes* in principle to the road that leads to the dehumanized hell of *Brave New World*."

But many disagree, arguing that such views show a romantic attachment and a fantasy view of what is "natural." Regarding the revolutionary aspects of modern medicine, Bill Haseltine of Human Genome Sciences is under no doubt: "I believe our generation is the first to map a possible route to individual immortality. When we know what, in effect, our cells know, health care will be revolutionized, giving birth to regenerative medicine—ultimately including the prolongation of life by regenerating our aging bodies with younger cells."

Program 5 examines the philosophical and ethical debates around modern advances in various technologies, with the capacity to change human evolution and set up unforeseen consequences. These include: preimplantation genetics, diagnosis, germline engineering, reproductive and therapeutic cloning, embryonic and adult stem cell research, nanotechnology, and designer drugs that will affect not only our future health and longevity but also the composition of the human species itself.

PROGRAM 6: The Horizons of Knowledge
Scale: The Mind

Program Content

What is the nature of human consciousness? What are the ethical implications of spawning other intelligent entities such as robots? Roboticist Hans Moravec thinks that the advent of intelligent robots will represent a pivotal point in human culture, much like the advent of writing, or of computers, or of the internet. "The first intelligent computers will provide us with unimaginable wealth brought on by the fantastic levels of productivity. Within 20 years, computers will be built that process information faster than human brains. By 2020 there is a technological singularity that enables us to move ahead very fast with the help of super-intelligent robots." And beyond that, Moravec sees robots as our path to immortality. Sometime in the future, he believes, we will possess the technology to "download" human consciousness—the contents of a human brain—into a machine. Robots, says Moravec, become "mind children," enabling us to transcend our biological fragility and live forever.

Rodney Brooks, who specializes in robotics and artificial intelligence at the Massachusetts Institute of Technology, claims: "Emotions are human beings' current last bastion of specialness. Computers are not only able to calculate better than humans but do many tasks better than humans. Computers are now better at doing symbolic algebra than are humans. We may have lost our central location in the universe; we may have lost our unique creation heritage; we may have been beaten out by machines in pure calculating and reason; but we still have our emotions. This is what makes us special. Machines do not have them, and human beings alone do."

Such talk strikes many humanists and theologians as hubristic and exaggerated, since Jews, Christians, and Muslims believe that man is created in God's image, and the idea of immortality seems profane.

With contributions from scientists, philosophers, theologians, and science fiction writers, this program examines the human mind in the world and the limits of what we can possibly know. "Prediction is extremely difficult," wrote the physicist Niels Bohr, "especially about the future." The issues are complex and perspectives vary, but the potential impact of human beings on natural systems is without precedent. In looking to the future, we must draw on the full range of human intelligence to understand and debate the options, and to make wise choices.

THEMES

The programs chronicle the inevitable clash between new perceptions of reality, as discovered by scientific inquiry, with older concepts of reality and religious views of the world. By looking into the impact of science and technology, we are able to engage in issues that have long obsessed humankind. This series brings into view ancient humanities debates involving time, human identity, and the human quest for the eternal in the midst of change.

Living with Rapid Change

We live in a time of momentous change. Alan Cutler, a research associate at the National Museum of Natural History, claims: "The transition that we are going through today for biological nature is analogous to what the 17th and 18th century transition was for the cosmos. The start of a new millennium provides an opportunity to consider how new ideas, new discoveries, and the accelerating pace of change fit into the larger patterns of nature and human history."

"In the past decade, it has become fashionable to speak of change as natural, and to discuss life from a planetary perspective," says Daniel Botkin, biologist at George Mason University. "New scientific methods and instruments allow us to track changes in the environment with ever greater precision …. We seem to be well on our way to accepting a new view of nature, one that accommodates its complexity, dynamism, and unpredictability …. But changing one's outlook on something as fundamental as nature isn't easy…. Throughout the history of Western civilization, for several thousand years, people have generally believed that there existed a great balance of nature, that nature, left alone, would inevitably achieve a permanent form and a constant structure. Down deep, we still wish for nature's benevolent constancy. We must learn to replace our idea of static beauty and perfection in biological nature with a new appreciation of the dynamics and processes in ecological systems."

A New Perspective

Envisioning humanity over the period of a thousand years seems difficult, if not impossible, but new developments in science and technology are opening up startling insights. The Earth's biosphere is the result of nearly four billion years of evolution but only in the 20th century have scientists been able to have some clear sense of the scope of the planet's history. Oceans have come and gone. Mountain ranges have risen and then eroded to nothing. Today computer technology is making it possible for Earth scientists to generate computer models of large-scale phenomena—mountain ranges, cycles of hot and cold global climates, entire biological populations—that are impossible to study in real time. It is just such scientific discoveries that enable us to take a new perspective, to take the long view.

"What happens in taking on projects that have a very long time horizon," says Stewart Brand, author and cofounder of the Long Now Foundation, "is that you look past your death, and your children's death. You look past your own mortality to appreciate human life and to ask the big questions: Was life on Earth a cosmic imperative or an accident? How does one planet result in an environment with a blue ocean and clouds while another remains a seared terrain that is 490 degrees centigrade? How did human beings respond to change? Either life makes it or it doesn't." Is humanity the crowning achievement of evolution or an afterthought?

To some, taking the long view simply acknowledges human mortality and frailty. Stephen Jay Gould said: "Obsession with the millennium reflects our suspicion

that the cosmos may feature neither sense nor direction, while we humans may inhabit this planet for no special reason and with no goal ordained by nature."

But to Joseph Coates, head of Consulting Futurist, Inc., looking ahead is a concrete process that borders on art. "There are several assumptions when mapping the future," he asserts. "We are talking about humanity, which has to do with all people. Our exploration involves no science fiction. It tracks science and technology developments and their reasonable extrapolations." Taking the long view, says Coates, magnifies human importance. It reflects the power of human intervention.

Concepts of Human Identity

Looking at the long-term future also brings into view the question of what it means to be human. How are we, as people, to define ourselves? Humans are confronted by a world where they move through time and space, usually in the time span of a human life. They search for personal identity through an ordering principle—the rhythms of days or one's place in a physical universe.

For millennia, the major theories of human nature have come from religion, says MIT cognitive psychologist Steven Pinker: In Judeo-Christian tradition, for example, "humans are made in the image of God and are unrelated to animals. The mind is an immaterial substance made up of several components, including a moral sense, an ability to love, and a capacity for reason …. This is still the most popular theory of human nature in the United States. According to recent polls, 76 percent of Americans believe in the Biblical account of creation; 76 percent believe in angels, the devil, and other immaterial souls; 67 percent believe they will exist in some form after their death; and only 15 percent believe that Darwin's theory of evolution is the best explanation for the origin of human life on Earth."

Such debates have been with us since humanity began. In ancient Greece, Pythagoras led a cult that worshiped the triangle, a perfect form, and believed that numbers had a separate existence outside time. Pre-Socratic philosophers struggled over notions of *becoming* or change versus *being* or permanence. Heraclitus believed that reality is flux and change: "You cannot step twice into the same river, for fresh waters are ever flowing in upon you." He suggested that flux and becoming alone are real, that permanence and constancy are merely apparent. In an effort to refute Heraclitus, Parmenides preached the logical impossibility of change, saying, "If anything is, it is now, all at once." Zeno, in his famous paradoxes of motion, also sought to prove that being was static.

Parmenides could not deny the evidence for change perceived by the senses. Instead he elevated reason, which could intuit the changeless, above the senses, which he considered untrustworthy. Plato also became enthralled with the notion of unchanging ideas lying beyond our transitory world of aging and death. Through Aristotle, this Platonic idea of a realm outside of time, perfect and eternal, came to influence the Church, which in turn profoundly influenced Western intellectual tradition.

New scientific and technological revelations view human nature in a different light. Dorion Sagan, author of *Microcosmos, Biospheres*, and Eric Schneider, former National Lab Director for the Environmental Protection Agency, argue that what we see as a constant identity is really an illusion. Human beings are a manifestation of continuous biochemical turnover, a ceaseless swirling of organic change: "The fact that the human mind is able to imagine eternity and its perpetual fascination with numbers, geometic shapes, and other changeless forms, has had a dramatic impact on our perception of reality. For the last few centuries, the timeless has been epitomized by the mathematical equations of the physicist, who has tried to discover eternal laws behind our changing natural world. It is curious that we should be so obsessed with the eternal when we live in a world of incessant change, where perhaps the most truly incorruptible, eternal, and changeless thing is our ability to even imagine such permanence."

Theories of Evolution

"We deny evolution because we have not been able to imagine the power of tiny change," said Darwin. Many harsh critics of Darwin's theory of evolution were physicists. The idea that complexity could arise naturally from chaos appeared to defy the newly formulated laws of thermodynamics. Later advances in biology and physics showed thermodynamics and evolution to be not only compatible but intimately connected. More recently, scientists such as Daniel Botkin view the universe as thoroughly evolutionary and permeated with change, to the point of suggesting that even the laws of the universe may change.

Dorion Sagan and Eric Schneider argue that the second law of thermodynamics is one case in point. The second law states that entropy tends inevitably to increase in isolated systems. They explain: "Thermodynamics, as it took shape in the l9th century, presented Victorians with a picture of the future taken from the gritty inner clunkings of imperfect heat-leaking steam engines. Today we realize that life is not reaching an end

state of equilibrium. Life takes in liquids, solids, and gases from the outside not only to function but to maintain and reproduce its internal organization. To live on. And yet change also moves in a direction of increasing complexity."

Why do complex things such as trees emerge from an equilibrium craving a thermodynamic world that tends toward disrepair? The answer to this was recognized by Nobel Prize-winner Erwin Schrodinger and is called the "Schrodinger Paradox." Schrodinger argued that life is not some metaphysical entity distinct from the material world. At the center of life he saw the gene—a material entity made up of a particular molecule—an entity that produced order from order. By feeding on the energy of the Sun (and the food it produces), living beings are able to resist the thermodynamic imperative to fall into final disrepair. Order can then emerge from disorder.

"The challenges and pleasures of life, both personally and cosmically," say Sagan and Schneider, "are not in achieving some sort of final stasis, permanence, stability, or eternity, but in the process of dealing with change, of energy flow and all the changing it inevitably entails. The combined evolution of humans and high technology raises the possibility that in the far future the universe *in toto* may be grist for life's thermodynamic gradient reducing mills. If this is so, life, despite its minuscule size, may be bound up with the immense task of changing the entire universe."

VISUALIZATION: HOW WE WILL APPROACH PRODUCTION

by Jon Palfreman, Executive Producer

A project this vast requires a considerable period of development. As noted elsewhere, the Foundation For the Future is to be applauded for promoting thinking around the basic concept of examining the future of humanity over an extended time period. The idea to do these programs started with interdisciplinary meetings, involving scientists and humanities scholars, but the television series takes this to a new level. In a documentary, form should follow content. The way to make a program is determined by what it is about.

Though we are talking about the future, humanities scholarship and scientific inquiry are essential in order to enable us to carve out into separate domains and determine lines of inquiry, research, and potential stories. The early Foundation For the Future workshops revealed that scholars could look back at human history and gain useful insights into some of the drivers that effect change in the human species. The workshops also engaged scholars working at the forefront of science, technology, philosophy, and ethics, encouraging them to explore the dimensions of changes on the immediate horizon—cloning, stem cell engineering, global climate change, and so forth. From this basis, scholars summoned the confidence to speculate, in an informed way, about the more distant future. The scholar workshops were designed to be highly interdisciplinary and inclusive, encompassing the span of human knowledge. The results were fascinating, free-ranging conversations. The open framework fostered an exciting intellectual synergy.

The notion of a television series initiated a new phase in the Foundation's efforts. The decision to shape this discussion into a series of television programs implied both a daunting intellectual challenge and an equally significant production challenge. How best to turn the contributions of dozens of scholars, all with their own expertise and viewpoints, into a meaningful series of programs that can inform and inspire a general audience?

In a television documentary, as in other media, it is crucial that form follows content. Trying to specify the production style in advance of the content is usually a recipe for failure. This project in particular needs careful content development before major production decisions are taken. While scholars can offer guidance in specific areas, there are currently no books that integrate the many ideas involved. There are no polymaths whose expertise covers more than a fraction of the intellectual territory involved. Our first task, therefore, has been to carve the intellectual landscape into distinct subject areas, so that they are individually manageable.

Currently, we see six program areas. For each program area, a producer will be assigned to work with scholars and map out a research essay that conceptualizes the topic and gathers together the best research, human examples, and scholarly opinion. This research paper will be reviewed by the editorial team and revised. Next, the producer will turn the research paper into a shooting script.

The programs will—like all programs—have to engage the audience on a human level. The stories—be they about culture or medical technology—take their appeal from being discussions of human nature and human behavior. It is probable, therefore, that producers will seek to engage the audience with current examples that encompass a conflict that we face. From this we will open the discussion, looking backwards in time and projecting forward.

One proven way of handling broad intellectual quests is to turn them into journeys of discovery. These programs will lead viewers to consider vast, sometimes troubling ideas. They will force the audience to conceptualize human life and society very differently from what they are accustomed to. The programs will encourage the viewers to examine human evolution and culture at a species level, enabling us to see some of the fundamental drivers of human culture.

Each program may use a single "time traveler" who goes on a journey, starting in the present, looking back into the past, and projecting forward into the future. At every stage, competing views and philosophies will be advanced, evidence will be examined, and understanding will deepen. Using location filming, archival footage and stills, careful re-enactments, and pre-enactments (including digital animation wizardry), these programs will employ state-of-the-art production values. But these films will not indulge in visual gimmickry.

RESOURCES AVAILABLE TO THE PRODUCTION

We will be creating defined sequences combining originally shot footage (on-location interviews) with high-end animations and archival footage. Larry Klein, potential producer, director, and writer of our program, has extensive experience in creating animated sequences for nationally broadcast documentaries (MacCauley series of *Pyramid*, *Cathedral*, *Roman City*). We may draw on animators such as CFC The Frame Store or Mike Milne in England. We also may make use of Schwartz/Giunta, a graphics company, and the Wright Center for Innovative Science Education at Tufts University, which both creates animations and has an important archive.

Thanks to the efforts of the Foundation For the Future, the production team has a network of scholars, the transcripts and videotapes of countless scholar meetings, and a library of books and periodicals. The production team will be drawn from the most experienced science and history producers in the world, with decades of experience. They have an enormous number of contacts and personal relationships with scientists, philosophers, archivists, museum directors, and educators.

RELATED PROJECTS

OUTREACH for Classroom Use

by John Banister-Marx

John Banister-Marx, a Fellow at the Wright Center for Innovative Science Education at Tufts University, was an advisor for the highly successful *Evolution* educational website, which offers a wide range of classroom resources for both teachers and students, such as an online digital library, teacher-training resources, lesson plans, and more. Mr. Banister-Marx drafted the following web plan as a structure for outreach that would accompany *The Next Thousand Years* series, using the *Evolution* site as a model. The work was funded in its entirety by the Foundation For the Future. With planning funds, the Foundation will be able consult with scholars and build content into this outreach structure.

GOALS

The goal of *The Next Thousand Years* Educational Outreach Program is to heighten public interest in, and comprehension of, the impact of science and technology on human cultural and biological evolution, as well as to show what historical patterns and developments reveal about the future toward which we, as a global community, may be headed. In addition to countering some common misconceptions, the series and its outreach will serve to encourage a national dialogue on the issues currently surrounding this broad array of subjects.

The Next Thousand Years Educational Outreach Program will feature a comprehensive and engaging website with an array of free educational and professional development resources aimed at a general audience, including interactive games, online expeditions and interviews, and animated narratives. The project's extensive educational outreach initiative will also seek to transform the way science and technology are taught and learned in schools nationwide by providing teachers with resources that expand their content knowledge, including an online digital library and downloadable teacher training, all emphasizing strong interdisciplinary connections.

PROFILE

The program encompasses, in addition to the broadcast series, an unprecedented array of resources for further learning at home and in school:

- Online library that features many multimedia resources, including video and photographic images, interviews, and annotated web links with an internal navigation aid for users.
- Content-rich, multimedia classroom resources (Quicktime video, web-based computer interactives,

etc.), and effective strategies for teaching about science and technology in an exciting interdisciplinary context.

- Educational materials that will explicitly target both national and state standards at specific curricular and grade levels, indexed for easy reference to increase access and usability.
- Free, accredited, online, professional development for teachers, incorporating video, interactive computer simulations, online collaboration, and customizable email list-serves and links.
- Informal educational outreach that will work with a consortium of science and technology centers, museums, and private institutions to develop web-cast community forums.
- National program of leadership training from a cadre of teacher specialists, from a sampling of grade-level and subject areas, to support other teachers in their use of the materials of *The Next Thousand Years* Educational Outreach Program.

DETAILS

Online professional development—A comprehensive web-based course designed to give teachers the necessary skills and background to utilize the educational materials designed for classroom use. The course offers in-depth interdisciplinary sessions on the cultural and societal impacts of major developments in science and technology. This online course for teachers will draw upon the broadcast series, interactive web activities, teacher methodology videos, and a multimedia web library to provide a vibrant, content-rich learning experience that is designed for both independent and collaborative learning among teachers.

The professional development/methodology videos (streamed online and on VHS and DVD) will present creative, effective, inquiry-based programs of teaching and learning about futurist issues. These videos of exemplary interdisciplinary classroom lessons will be conducted by resourceful teachers in diverse schools around the United States. The videos will be pioneered by a group of creative curriculum developers brought together early in the planning phases.

Classroom videos (streamed online and available on VHS and DVD)—Entertaining videos (5–7 minutes) designed for three age groups of students (K–4, 5–8, 9–12), exploring science, technology, and societal ideas from *The Next Thousand Years* video series and answering key questions students frequently ask (the source for these questions will be a student essay contest begun in late 2002): How will imminent energy shortages affect transportation? What will the future of communication be like? These short educational videos will feature real students asking grade-level-appropriate questions that explore pertinent, interdisciplinary, grade-level content. Each will combine engaging storytelling with scientific inquiry to explore fundamental concepts.

A web library that provides the premier web source for multimedia materials on futurist issues—an online collection of film and video clips, photographs, graphics, and key historical and contemporary documents. These materials will be digitized, catalogued, and annotated for easy reference, all designed to enhance student learning and classroom teaching.

Engaging, self-guided student lessons online, employing project film, video, and interactive media resources for in-depth studies that meet national and state standards for science and technology education, and other disciplines.

A free printed teacher's guide summarizing the resources to support classroom teaching. The summary features guidelines for utilizing the dozens of classroom activities, content information, discussion questions, and teaching strategies available on the web and on a DVD-ROM (which includes guided navigation tutorial) that educators can employ successfully with or without access to *The Next Thousand Years* broadcast series or other project media. Additional teacher support will include streamed online teacher videos of the instructional materials as used by master teachers in their own classrooms.

A national program of leadership development in interdisciplinary science and technology education—intensive training for 25 educators each year for three years as leaders of district, state, and national workshops on the teaching of futurist issues in K–4, 5–8, and 9–12 classrooms. These "lead" teachers will help colleagues develop their knowledge of futurist issues and improve their classroom teaching strategies by staging eight-hour, for-credit, short courses throughout the country and possibly the world.

A companion book, written by a noted science journalist and a panel of scientists and sociologists, will provide a comprehensive and engaging investigation of issues surrounding science and technology, their link to or influence on major historical or cultural developments, and the role each will play on the future of factors as diverse as communication, transportation, human reproduction, etc.

TIMELINES

Year One

- Develop the framework for *The Next Thousand Years* website. Post mission, development phase information, and guidelines for student essay competition and teacher curriculum submission (details noted below).
- Develop a student essay contest, to be conducted annually for four years, to solicit student "profiles of the future." Students compete by region (e.g., Rocky Mountain, Pacific Northwest, Southwest, Northeast, etc.). Regional winners will be chosen in each of three age ranges: K–4, 5–8, and 9–12. Modest prizes will be awarded to regional winners, and an award on the order of a trip to EPCOT for the family will be given to national grand-prize winners in each age category. (Through this competition young people can provide useful feedback on game scenarios for online interactives and also provide the questions needed to develop the classroom videos.)
- Select a core group of one educational outreach coordinator and three grade-level "core lead teacher" specialists to develop a plan for the phases of curriculum development and evaluation of student essay competitions, which are to take place in summers 2003, 2004, and 2005.
- Advertise in teacher trade journals like *NEA Today*, *Teacher Magazine*, and subject magazines for the National Science Teachers Association (NSTA) and National Association of Biology Teachers (NABT). This will provide a view of our mission and curriculum needs for the Educational Outreach Program.
- Develop a series of educational "curriculum specialist" awards on historical, interdisciplinary science and technology content with an organization like the NSTA. Teachers who submit curricular proposals into competition and win will be likely candidates for the later curriculum development phase.
- Work with the educational outreach coordinator and core lead teachers to convene the first of three workshops for 25 teacher "curriculum specialist" awardees. These one-week workshops will be conducted, one per summer over three summers, to address the curriculum-development needs of the project. Each workshop will include educational outreach training for teachers in conducting their own one-day workshops to promote the upcoming series and its curriculum content.

Year Two

- Provide a budget to Year One curriculum specialists to produce one-day teacher workshops on the theme "the next thousand years." Recommended venues are state, regional, or national conventions. From these workshops, Phase 2 curriculum specialists can be recruited and later trained.
- Present the second set of student essay awards.
- Convene the second one-week summer workshop for Phase 2 curriculum specialists. Several Phase 1 curriculum specialists, the educational outreach coordinator, and core lead teachers should also participate. Begin Phase 2 curriculum writing and development of teacher professional-development materials, including the writing and taping of the professional-development videos to accompany activities in the curriculum.
- Solicit and deliver early curricular materials to pilot testing sites for use and evaluation of materials.
- Present the first set of awards honoring teachers who incorporate innovative curricula to teach futurist issues through the societal impacts of science and technology. (See No. 5 under timeline for Year One.)

Year Three

Similar scenario to that of years One and Two above plus the following activities:

- Oversee use and evaluation of materials by pilot testing sites.
- Present the second set of awards honoring teachers who incorporate innovative curricula to teach futurist issues through the societal impacts of science and technology.
- Honor the third set of winners of the student essay contest. (The essay contest could be continued indefinitely to provide an ongoing source of information on adolescent interests and to continue to spark interest in futurist issues.)
- Assist Year One and Two curriculum specialists to produce the second round of one-day teacher workshops. Identify Phase 3 curriculum specialists for the one-week summer program.
- Conduct the third annual one-week summer workshop for Phase 3 curriculum specialists. Participants should also include several Phase 1 and 2 curriculum specialists, the educational outreach coordinator, and core lead teachers. Review and edit piloted materials,

and teacher professional development materials and videos.

Year Four

Similar scenario to that of years One, Two, and Three plus the following activities:

- Commence worldwide, web-cast, community forums one year before the series release. The forums will be held at locations around the world every two months, with three of the six forums held in the United States, and three abroad. Future software development might make international translation possible around the world for major languages. The forums will allow people to share ideas prior to the airing of the video series, and will build worldwide momentum for interest in the series and the issues it will address. The Wright Foundation presents worldwide, web-cast colloquia in Geneva, Switzerland, every even year in October. On odd years Tufts University hosts a web-cast in October. These two sites would be functional sites to develop the web-cast plan.
- Introduce professional development videos at major educational convention(s) like NSTA, along with the final edits of the curriculum and web materials. Convene sessions at the convention and maybe in a large feature area in the Exhibition Hall.
- Present the third set of awards honoring teachers who incorporate innovative curricula to teach futurist issues through the societal impacts of science and technology. (These annual awards could be continued indefinitely to find and utilize the best practices and materials available.)
- Honor the fourth set of winners of the student essay contest.

Year Five

- Air prime-time *The Next Thousand Years* video series.
- Continue to give awards and develop/edit curricula as a way to maintain momentum gained leading up to *The Next Thousand Years* series. The biennial update programs will maintain the interest of the general viewing public as well as of students and classroom teachers.

Outreach for Non-Classroom Materials by IN, inc.

IN, inc., a creative agency based in Seattle, Washington, has been brought on board to create other, non-classroom web materials to engage young people in out-of-school settings, such as Boys and Girls Clubs, libraries, science centers, museums, and at home. One idea in development is a web-based *Civilization*-like simulation game, which would enable users to manipulate various factors of future scenarios and learn from the consequences of their decisions in an interactive, online environment. IN, inc. has developed such materials before for the Carnegie Science Center in Pittsburgh, Sesame Workshop, Boys and Girls Clubs of America, and the PBS series *Arthur* and *Bill Nye the Science Guy*, among many others. IN, inc. will draft a plan for web outreach under the auspices of this planning grant.

Promotion/Dissemination Plans

The promotion plan for the finished series and associated educational outreach is still being developed. To date, the Foundation has publicized its plans to produce a series to the hundreds of scholars that participate in its other programs. Information about the planning for the series is also available in the Foundation's newsletter and on its website. These strategies are designed to generate early interest in and awareness of the project among potential scholar collaborators, producers, audience members, and others. The results of the planning grant will be shared with scholars (both those already committed to the project and potential collaborators), with experienced producers whom the Foundation would like to invite to work on the series, and with other interested parties. As the project progresses, we will seek a public television station to present the series nationally. Executive Producer Jon Palfreman has had preliminary discussions with Beth Hoppe, Director of Science Programs at Thirteen/WNET New York, who has expressed interest in the project.

HISTORY OF THE PROJECT

The initial concept for the television and outreach project grew out of Humanity 3000, an ongoing program of the Foundation For the Future. To date, 150 international scholars from 40 intellectual and professional disciplines have participated in workshops and symposia. Among the scholars are prominent thinkers, humanists, and scientists including Nobel laureates. They came to discuss trends in science, technology, and human cultural development. All the discussion sessions are recorded and transcripts published for public use. The trustees of the Foundation and the scholars participating in the programs have been eager to find a way to share this information more broadly and to promote general awareness of futures issues with the public in formats that are appealing and thought-provoking. The Foundation decided to explore mass media, especially television, as one option.

In late winter 2001, the Foundation began planning discussions with Jon Palfreman, a noted science documentary producer (NOVA/Frontline) and asked him to

serve as Executive Producer for what was then an eight-part television series. In the spring, Anna Reid Jhirad prepared a consultation proposal for the NEH and submitted it to NEH.

A few days later, the Foundation convened a two-day preliminary planning workshop, April 19–21, 2002, in Bellevue, Washington, with 28 scientists, humanities scholars, and eminent film producers in attendance. The objective was to brainstorm about the series content and approaches, and to discuss what major issues should—and could—be addressed effectively through television and educational outreach. In preparation for this meeting, Kirk Citron, an award-winning writer with extensive experience in reaching broad audiences through marketing and advertising campaigns, drafted eight program sketches for the series based on ideas from the Humanity 3000 seminars. Each episode explored a different topic, such as humanity's impact on the planet, advances in medicine, artificial intelligence, economics, and more. These sketches were sent to participating scholars and producers as a starting point for discussion.

Workshop participants reached several conclusions after two days of dialogue and debate. They agreed that the television series would benefit from revising the framework to a series of six (rather than eight) episodes, each following several time travelers or experts who will elucidate humankind's knowledge of the past, bring us up to date on current trends, and take us on a journey to the near and far future. The time travelers will be prominent scholars, humanists, scientists, or others who have spent their lives considering such journeys into the future or past. The team decided to locate the series in the present, establish current contexts with respect to major transformations taking place in human cultural development, call attention to our vulnerabilities in a rapidly globalizing planet, and outline our struggles to deal with these transformations. The Foundation For the Future recorded the entire meeting, including plenary and smaller sessions. Transcripts were published in the *First Producers Workshop Report* in August 2002.

In July 2002, the project was funded by NEH for consultation. Our objectives during the consultation phase have been to sponsor a dialogue between humanists and scientists on the program topics and to develop a preliminary plan for the project's format, design, and story lines. We have made use of meetings as well as telephone conversations and email to confer with our scholars, conduct further research into each program, and to develop the story lines. We have drawn on insights from both a core team of scholars and specialists for each program. The consultation process has enabled us to shape the series and ground it more solidly with insights and analytical perspectives drawn from a range of humanities disciplines.

AUDIENCE AND BROADCAST PROSPECTS

We will target a broad national audience on public television with this six-part television series. Based on the success of *Evolution*, which was somewhat similar in theme and presentation style, we estimate that *The Next Thousand Years* will reach approximately 15 million viewers nationwide. The producers have long-established relationships with the major PBS stations such as WGBH and WNET, and anticipate no problem in bringing this series to air. Informal discussions have taken place, but we have decided to develop the series further before selecting a broadcast partner. In addition, other audiences will be reached through print materials, educational and outreach components, and *The Next Thousand Years* website, as well as through local exhibitions and displays. In some cases, we will foster exhibitions at appropriate museums. We are developing networks, such as collaborations with the Glaser Foundation, to promote exhibitions, scholarly talks, and conferences on futures issues.

ORGANIZATION HISTORY

The Foundation For the Future was established in Bellevue, WA, in 1996 by inventor Walter Kistler and Bob Citron, to pursue the mission of increasing and diffusing knowledge concerning the long-term future of humanity. Walter Kistler also founded Kistler Instrument Corporation (1957), and co-founded Kistler Morse Corporation (1980) and Kistler Aerospace Corporation (1993). He holds patents on more than 50 inventions in the scientific and industrial instrument field, and is the recipient of numerous awards for his inventions and as a space pioneer.

The Foundation For the Future has engaged in a broad range of activities focused on its mission, including the sponsorship of basic research into the social, genetic, biological, medical, psychological, physiological, cultural, and environmental factors that have or will have an impact on the quality of human life.

In announcing the establishment of the Foundation For the Future, Mr. Kistler said, "There are many public and private foundations and international organizations that attempt to deal with current and near-term future problems affecting the quality of human life. The Foundation For the Future will focus its attention on

the long-term survivability of humanity and support research and symposia that have a purpose of identifying the most critical factors that may improve the quality of future human life on Earth. As we approach the year 2000, it is appropriate to bring together the best minds on planet Earth to contemplate the next thousand years, indeed, the next several thousand years, of the cultural and biological evolution of the peoples of the Earth."

To accomplish its goals, the Foundation encourages scholarly debate on how society should best proceed in light of the results obtained from current research, and publishes the results of its activities for the research community, for public policy-makers, and for the general public.

The first major program of the Foundation, Humanity 3000, is a series of seminars and symposia that bring together some of the world's most prominent scholars: scientists, philosophers, humanists, historians, technologists, and futurists. The scholars are asked to assess the current status of humanity, to identify the most significant factors that may affect the future quality of life of the people of the Earth, and to discuss and debate the topics they consider to be most important to humanity's survivability during the coming millennium.

To fulfill its mandate of increasing and diffusing knowledge concerning the long-term future of humanity, the Foundation also conducts a research grants program to provide financial support to scholars; awards the annual Kistler Prize for original work in the relationship between the human genome and society; publishes scholarly works that address issues concerning the future quality of human life; and undertakes public awareness and education programs concerning the long-term future of humanity.

The Foundation For the Future has assembled teams of prominent scholars and humanists to serve on the Foundation's Board of Advisors, on the Kistler Prize Advisory Panel, and on the Organizing Committee for the Foundation's Humanity 3000 program.

PROJECT STAFF

Jon Palfreman, Executive Producer, is an award-winning producer, executive producer, and writer with more than one hundred major programs on science, technology, and medicine that have aired on BBC and PBS. Recent programs include the Peabody Award-winning series *The Machine That Changed the World* (about the history of computers), the Emmy Award-winning NOVA *Siamese Twin*, and the Alfred I. DuPont Award-winning NOVA/*Frontline* special *Harvest of Fear*. He is a three-time winner of the AAAS/Westinghouse Science Journalism Award, three-time winner of the National Association of Science Writers "Science and Society" Award, and a winner of the Writers Guild of America award for best script. The author of two books, Palfreman is the only television producer to win the prestigious Victor Cohen Award for Excellence in Medical Writing.

Larry Klein, potential Producer-Director-Writer, is an eminent filmmaker with a long career in both the sciences and the humanities, winning the Emmy, Cine Golden Eagle, American Film and Video Festival Red and Blue Ribbons, and George Foster Peabody Award. He has been executive producer as well as producer, director, and/or writer of many programs for national television, among them: *The Legendary West*; *Lewis Mumford: Toward Human Architecture*; the David Macaulay series (*Castle, Cathedral*, *Pyramid*, *Roman City*, and *Mill Times*); *Mysteries of the Senses: Hearing*; *Who Plays God?* on life and death decisions in the American health care system; *Science Odyssey: Matters of Life and Death*; *Building Big,* on engineering achievements; *Why the Towers Fell*, on the collapse of the World Trade Center on September 11, 2001, among others.

Consulting Producers. Other producers have worked with us during the consultation phase and in the shaping of the series as a whole. We will select producers for individual programs from the following: *David Axelrod*, Green Umbrella USA, Los Angeles; *Michael Barnes*, Windfall Films Ltd., London; *Noel Buckner and Rob Whittlesey*, The Documentary Guild, Boston, MA; *Carl Charlson*, WGBH-TV, Boston, MA; *Mark Davis*, MDTV Productions, Newburyport, MA*; David Dugan*, Windfall Films Ltd., London*; Gary Glassman*, Providence Pictures, Inc., Providence, RI; *Sue Houghton*, RDF Media, Sherman Oaks, CA; *Ben Loeterman*, Ben Loeterman Productions, Boston, MA; *Daniel McCabe*, Big House Productions, Arlington, MA; *Larkin McPhee*, Minneapolis, MN*; Joel Olicker*, Powderhouse Productions, Inc., Somerville, MA; *Nancy Porter*, Nancy Porter Productions, Inc., Lexington, MA; *Kate Raisz*, Documentary Films, Arlington, MA; *Kirk Wolfinger*, Lone Wolf Pictures, South Portland, ME.

Kirk Citron, Supervising Writer, is an award-winning writer and advertising entrepreneur. A graduate of Harvard, where he studied anthropology and film, he has been inducted into the American Advertising Federation's Hall of Achievement and has won five Clios.

The Foundation Team

Bob Citron, Series Project Director, is Executive Director and co-founder of the Foundation For the Future. He was formerly founding President and Chief Executive Officer of Kistler Aerospace Corporation. Citron spent 20 years at the Smithsonian working with many of NASA's space projects. He helped establish the Smithsonian's global Satellite Tracking Network in Europe, Africa, and Asia, and was a pioneer in satellite orbit determination and precision optical tracking. He also founded several successful companies in the fields of science communications, education, publishing, and commercial space systems, including EARTHWATCH and SPACEHAB, INC. Citron co-invented the SPACEHAB module concept, which has been used on 15 Space Shuttle missions.

Sesh Velamoor is Deputy Director, Programs, for the Foundation For the Future. He serves as the Foundation's Chairperson responsible for the television series Advisory Board. He has been President and board member of Kistler-Morse Corporation, a teacher of business at Portland State University, and Foundation Associate of the Pacific Science Center.

Donna Hines, Deputy Director, Administration, Foundation For the Future, is Project Coordinator on the television series.

Kathy Carr is Special Projects Manager for Foundation administration and assistant to Donna Hines.

Outreach Teams

For classroom materials: John Banister-Marx, Wright Center for Innovative Science Education at Tufts University.

For non-classroom materials: Ian G. Saunders and Barry Ross Rinhart, founders and directors of IN, inc., a Seattle-based creative agency that specializes in creating fun, effective materials for children. From entertainment to education, broadcast television to outreach, IN, inc. has a long history of success in the field of children's education and science learning, including projects for Boys and Girls Clubs of America. IN, inc. has produced outreach programs such as *Fitness Authority*, *Cavity-Free Zone, Image Makers*, and *Body Works*. The company has written for PBS programs such as *Arthur*, *SciSquad*, and *Bill Nye the Science Guy*, and worked with The Discovery Channel and museums around the United States, including the American Museum of Natural History, EPCOT Inventions Pavilion, and Washington State History Museum.

Board of Advisors

William Calvin is a theoretical neurophysiologist at the University of Washington in Seattle. He is the author of *The Cerebral Code*, *How Brains Think*, *The River that Flows Uphill*, and *The Throwing Madonna.* His research has focused not only on the development of the brain but on paleoclimate and oceanographic research on the abrupt climate changes of the ice ages.

Eric Chaisson is Director of the H. Dudley Wright Center for Innovative Science Education at Tufts University where he is a Research Professor of physics and astronomy. He also served for ten years as a member of Harvard's Faculty of Arts and Sciences. His research has focused on the radio astronomical study of interstellar gas clouds.

Richard Dawkins is the Charles Simonyi Professor of Public Understanding of Science at Oxford University. He is a lecturer in zoology and the author of *The Selfish Gene*, *The Blind Watchmaker*, *Unweaving the Rainbow*, and other publications on evolution and ethology.

Steven J. Dick is the Historian of Science at the US Naval Observatory. He is the author of *Plurality of Worlds: The Origins of the Extraterrestrial Life Debate from Democritus to Kant* and *The Biological Universe: The Twentieth Century Extraterrestrial Life Debate and the Limits of Science*.

Faye Duchin is the Dean of the School of Humanities and Social Sciences at Rensselaer Polytechnic Institute in Troy, New York, where she is also Professor of economics. She is the author of *Structural Economics: Measuring Change in Technology, Lifestyles, and the Environment.*

Brian Fagan is Professor of archeology and anthropology at the University of California at Santa Barbara. He is a specialist in pre-European African history and archeology, as well as American and general archeology.

Clive Gamble is Professor of archeology at the University of Southampton in England. He is the author of *The Prehistory of Global Colonization* and other works on prehistoric Europe.

Susantha Goonatilake is a sociologist and Visiting Scholar at the Center for the Study of Social Change, New School for Social Research in New York. He has worked with the United Nations and has been a Senior Consultant for all the UN organs dealing with knowledge and science and technology issues. He is the author of *Toward a Global Science: Mining Civilizational Knowledge.*

John Leslie is Professor Emeritus of philosophy at the University of Guelph in Ontario, Canada. He is the author of *Value and Existence*, *Physical Cosmology and Philosophy*, and *The End of the World*.

Ilya Prigogine is Regental Professor and Ashbel Smith Professor of physics and chemical engineering at the University of Texas. He won the Nobel Prize in chemistry in 1977 for his contributions to nonequilibrium thermodynamics. A major theme of his research has been a better understanding of the role of time in the physical sciences and biology.

Brian Swimme is Professor of philosophy at the California Institute of Integral Studies in the Department of Philosophy, Cosmology, and Consciousness in San Francisco. His research focuses on the time developmental nature of the universe and the role of the human within evolutionary dynamics. He is the author of *The Hidden Heart of the Cosmos* and other books, and contributed to the BBC television production of *Soul of the Universe*.

Peter D. Ward is Professor of geological sciences, Professor of zoology, and Curator of Paleontology at the University of Washington in Seattle. He is author of *Rare Earth: Why Complex Life is Uncommon in the Universe* and *Future Evolution*. He was editor of *Global Catastrophes in Earth History*, sponsored by the National Academy of Science and NASA.

Edward O. Wilson is the Pellegrino University Research Professor and Honorary Curator of Entomology at Harvard University. He is a preeminent biological theorist. Two of his books have won the Pulitzer Prize: *On Human Nature* and *The Ants*. He is the author of 20 other books including *Sociobiology: the New Synthesis*.

Additional Advisors for Individual Programs

David Perkins is the Senior Research Associate at Harvard's Graduate School of Education. He specializes in mathematics and artificial intelligence. His research on creativity has resulted in numerous books, including: *The Mind's Best Work*, *The Teaching of Thinking*, and others.

S. Fred Singer is an atmospheric physicist and founder of the Science and Environmental Policy Project, a think-tank on climate and environmental issues. He represents a skeptical voice on the issues of global warming, depletion of the stratospheric ozone layer, acid rain, and energy issues.

Sir Crispin Tickell is Chancellor of the University of Kent at Canterbury; Chairman of the Climate Institute of Washington, DC; Chairman of the Advisory Board of the Earth Centre in South Yorkshire; and Chairman of the Advisory Committee on the Environment of the International Council for Science.

PLAN OF WORK

Year One (2002): Project planning; writing the master project plan; drafting program treatments; identifying and recruiting scholar consultants; identifying potential co-production companies; completing a demonstration reel and series presentation materials; developing budgets and schedules; and identifying and negotiating with potential funding sources.

Year Two (2003): Pre-production planning; fundraising; concluding co-production agreements; hiring program producers and writers; holding program workshops with consulting scholars and writers; identifying interviewees and shooting locations; deciding on dramatic segment re-creations; identifying and writing computer graphic animations for each program; writing and reviewing program scripts; setting up logistics for shooting locations; and preparing detailed program budgets and shooting schedules.

Years Three and Four (2004, 2005): Production and post-production.

Year Five (2006): Broadcast.

PRODUCERS AND ADVISORS INVOLVED IN CONSULTATION PROCESS

The Foundation For the Future has held a series of workshops, seminars, and symposia during the past five years. Dozens of scholars from across the United States, Europe, and Asia have gathered to discuss and debate the most important factors affecting the long-term future of humanity. This ongoing project focuses on issues facing humanity during coming millennia, such as issues related to the origin and evolution of the universe, the origin and evolution of life on our planet, the origin and evolution of the hominid species and our human culture, and the long-term prospects for our human future.

Subject areas have covered a wide range of provocative questions: When did the universe begin and how did it evolve to its present state? When did the solar system and the Earth emerge in our galaxy? How and when did life evolve on Earth? What are the factors that led to the emergence of mammals and our hominid species? How did human culture evolve in the last million years? What are the major factors that will have an impact on

the evolution of human culture during the next thousand years? What role will science and technology play in the evolution of the human species? How will our mastery of genetic technology affect the future of human evolution? What are the future prospects for humanity if it masters nanotechnology? What impact will contact with extraterrestrial intelligence have on the future of human culture?

Proceedings of two seminars and one symposium have been published and are available for downloading from the Foundation's website.

In addition, we have consulted with scholars and film producers in developing the television series:

Producer Participants, April 2002 Workshop

Mr. David Axelrod, Green Umbrella USA, Los Angeles, CA USA

Mr. Noel Buckner, The Documentary Guild, Boston, MA USA

Mr. Carl Charlson, WGBH-TV, Boston, MA USA

Mr. Mark Davis, MDTV Productions, Newburyport, MA USA

Mr. David Dugan, Chairman, Windfall Films, London, UK

Mr. Gary Glassman, Providence Pictures, Inc., Providence, RI USA

Ms. Sue Houghton, RDF Media, Sherman Oaks, CA USA

Mr. Larry Klein, Production Group, Inc., Washington, DC USA

Mr. Ben Loeterman, Ben Loeterman Productions, Boston, MA USA

Mr. Dan McCabe, Big House Productions, Arlington, MA USA

Ms. Larkin McPhee, Minneapolis, MN USA

Mr. Joel Olicker, Powderhouse Productions, Somerville, MA USA

Mr. Jon Palfreman, President, PFG Productions, Lowell, MA USA

Ms. Nancy Porter, Nancy Porter Productions, Arlington, MA USA

Ms. Kate Raisz, Documentary Films, Watertown, MA USA

Mr. Rob Whittlesey, The Documentary Guild, Boston, MA USA

Mr. Kirk Wolfinger, Lone Wolf Pictures, South Portland, ME USA

Scholar Participants, April 2002 Workshop

Mr. Stewart Brand, President, The Long Now Foundation, Sausalito, CA USA

Dr. William Calvin, Theoretical Neurophysiologist, Department of Neurobiology, Psychiatry, and Behavioral Science, University of Washington, Seattle, WA USA

Dr. John Delaney, Professor, School of Oceanography, University of Washington, Seattle, WA USA

Dr. Brian Fagan, Professor, Department of Anthropology, University of California at Santa Barbara, Santa Barbara, CA USA

Dr. Panos Ioannou, Group Leader, Cell and Group Therapy Research, The Murdoch Institute, The Murdoch Children's Research Institute, Royal Children's Hospital, Melbourne, Victoria, Australia

Dr. Michael Shermer, Editor-in-Chief, *Skeptic* Magazine, Millennium Press, Inc., Altadena, CA USA

Dr. Gregory Stock, Director, Program on Medicine, Technology, and Society, School of Public Health, University of California, Los Angeles, CA USA

Dr. Woodruff T. Sullivan III, Professor, Department of Astronomy, University of Washington, Seattle, WA USA

Sir Crispin Tickell, Chancellor, University of Kent at Canterbury, Cirencester, Gloucestershire, UK

Dr. Peter D. Ward, Professor, Department of Geological Sciences, University of Washington, Seattle, WA USA

Dr. Rush Spencer Wells, Research Fellow, Trinity Hall, Castle Hedingham, Essex, UK

BIBLIOGRAPHY OF HUMANITIES SOURCES

Alperovitz, Gar. *The Decision to Use the Atomic Bomb*, New York: Vintage Books, 1995.

Anderson, Walter Truett. *Future of the Self: Inventing the Postmodern Person*. Putnam Publishing Group, 1997.

Aron, Cindy. *Working at Play: A History of Vacations in the United States*. Oxford University Press, 2001.

Asimov, Isaac. Collected Works.

Ayres, Edward. *God's Last Offer: Negotiating for a Sustainable Future*. Four Walls Eight Windows, 1999.

Ayres, Robert U. *Eco-Restructuring: Implications for Sustainable Development*. UNU Press, 1998.

Bailey, Ronald. *The True State of the Planet.* Free Press, 1995.

Baldi, Pierre. *The Shattered Self: The End of Natural Evolution*. MIT Press, 2001.

Bak, Per. *How Nature Works: The Science of Self-Organized Criticality*. Springer-Verlag, 1996.

Barash, David. *Revolutionary Biology*. Transaction Publishers, 2001.

Barrow, John. *Theories of Everything*. Fawcett Columbine, 1991.

Baxter, Burke. *Tomorrow's World*. BBC, 1970.

Boorstin, Daniel. *The Discoverers: A History of Man's Search to Know His World and Himself.* Penguin, 1983.

Brand, Stewart. *The Clock of the Long Now: Time and Responsibility*. Basic Books, 1999.

Brown, Lester. *Building a Sustainable Society*. Norton, 1981.

Burke, James. *Connections*. Little, Brown and Company, 1978.

Burnham, Van, and Ralph H. Baer. *Supercade: A Visual History of the Videogame Age, 1971–1984*. MIT Press, 2001.

Buzan, Barry, and Gerald Segal. *Anticipating the Future*. Simon and Schuster, 1998.

Canter, Norman. *Civilization of the Middle Ages*. Harper Collins, 1993.

Capra, Fritjof. *The Turning Point: Science, Society, and the Rising Culture*. Simon and Schuster, 1982.

Cavalli-Sforza, Luigi Luca. *Genes, Peoples, and Languages*. North Point Press, 2000.

Cohen, Daniel. *The Wealth of the World and the Poverty of Nations*. MIT Press, 1998.

Cradall, B. C. *Nanotechnology: Molecular Speculations on Global Abundance*. MIT Press, 1996.

Damasio, Antonio. *The Feeling of What Happens: Body and Emotion in the Making of a Consciousness*. Harcourt Brace, 1999.

Davies, Paul. *The Cosmic Blueprint: New Discoveries in Nature's Creative Ability to Order the Universe*. Simon and Schuster, 1988.

Dawkins, Richard. *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design*. W. W. Norton and Company, 1996.

Deacon, Terrence. *The Symbolic Species: The Co-evolution of Language and the Brain*. W. W. Norton and Company, 1997.

Dennett, Daniel. *Darwin's Dangerous Idea: Evolution and the Meanings of Life.* Simon and Schuster, 1995.

Diamond, Jared. *Guns, Germs, and Steel: The Fates of Human Societies*. Norton, 1997.

Dyson, Freeman. *Disturbing the Universe: A Life in Science*. HarperCollins Publishers, 1979.

Dyson, Freeman. *Weapons and Hope*. Harper and Row, Publishers, 1984.

Ehrlich, Paul. *Population, Resources, Environment*. Freeman, 1972.

Elgin, Duane. *Promise Ahead: A Vision of Hope and Action for Humanity's Future*. HarperCollins Publishers, 2000.

Fagan, Brian. *Floods, Famines and Emperors: El Niño and the Fate of Civilizations*. Basic Books, 1999.

Foundation For the Future. Proceedings of Humanity 3000 seminars, symposia, and workshops. Bellevue, Washington, 1999–2001.

Fraser J. D. *Voices of Time: A Cooperative Survey of Man's Views of Time as Expressed by the Sciences and by the Humanities*. New York: George Braziller, 1966.

Fukyama, Francis. *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus and Giroux, 2002.

Fukyama, Francis. *The End of History and the Last Man*. New York: The Free Press, a division of Schuster and Schuster, 1992.

Garrett, Laurie. *The Coming Plague: Newly Emerging Diseases in a World out of Balance*. Viking Penguin, 1994.

Glantz, Michael. *Currents of Change: El Niño and La Niña Impacts on Climate and Society*. Cambridge University Press, 1996.

Godbey, Geoffrey. *The Evolution of Leisure: Historical and Philosophical Perspectives*. Venture Publishing, 1988.

Gold, Thomas. *The Deep Hot Biosphere: The Myth of Fossil Fuels*. Springer-Verlag, 1999.

Goonatilake, Susantha. *Toward a Global Science: Mining Civilizational Knowledge*. Indiana University Press, 1998.

Gould, Stephen Jay. *Ever Since Darwin: Reflections in Natural History*. W. W. Norton, 1977.

Gould, Stephen Jay. *Questioning the Millennium*. New York: Harmony Books, a division of Crown Publishers, 1997.

Gould, Stephen Jay. *The Mismeasure of Man*. New York: W. W. Norton, 1996. Reprinted 1981.

Hawken, Paul. *The Ecology of Commerce: A Declaration of Sustainability*. HarperCollins Publishers, 1993.

Henderson, Hazel. *Building a Win-Win World: Life beyond Global Economic Warfare*. Berret-Koehler Publishers, 1996.

Hochschild, Arlie, and Anne Machung. *The Second Shift: Inside the Two-Job Marriage*. Viking Penguin, 1989.

Howe, Leo, and Alan Wain. *Predicting the Future*. Cambridge University Press, 1993.

Huntington, Samuel P. *Clash of Civilizations and the Remaking of World Order.* Simon and Schuster, 1996.

Jensen, Arthur. *The g Factor: The Science of Mental Ability*. Praeger, 1998.

Kagan, Donald (Ed.) with Brian Tierney and L. Pearce Williams. *Great Issues in Western Civilization*. McGraw-Hill, 1992.

Kagan, Donald. *On the Origins of War and the Preservation of Peace*. New York: Anchor Books, Doubleday, 1995.

Kaku, Michio. *Visions: How Science Will Revolutionize the 21st Century.* Anchor Books, 1997.

Kass, Leon and James Q. Wilson. *The Ethics of Human Cloning*. American Enterprise Institute Press, 1998.

Kevles, Daniel J., and Leroy Hood (Eds.). *The Code of Codes: Scientific and Social Issues in the Human Genome Project*. Harvard University Press, 1992.

Korten, David. *The Post-Corporate World: Life after Capitalism*. Berret Koehler, 1999.

Küng, Hans. *A Global Ethic*. Oxford University Press, 1998.

Kurzweil, Ray. *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking Penguin, 1999.

Kurzweil, Ray. *The Age of Intelligent Machines*. Cambridge: MIT Press, 1992.

Lacey, Robert. *The Year 1000: What Life Was Like at the Turn of the First Millennium*. Little, Brown and Company, 1999.

Laszlo, Ervin. *Macroshift 2001–2010: Creating the Future in the Early 21st Century.* Berrett Koehler, 2001.

Lietaer, Bernard. *The Future of Money*. Century, 2000.

Lorie, Peter, and Sidd Murray-Clark. *History of the Future: A Chronology.* Doubleday, 1989.

Lynch, Lundquist. *Digital Money*. Wiley, 1996.

Mann, Jim. *Tomorrow's Global Community: How the Information Deluge Is Transforming Business and Government.* Bain Bridge Books, 1998.

Mayor, Federico, and Jérôme Bindé. *The World Ahead: Our Future in the Making*. Zed Books/UNESCO Publishing, 2001.

Mayur, Rashmi. *Earth, Man and Future.* International Institute for a Sustainable Future, 1996.

Minsky, Marvin. *The Society of Mind*. Simon and Schuster, 1986.

Negroponte, Nicholas. *Being Digital*. Knopf, 1995.

Paul, Gregory S., and Earl Cox. *Beyond Humanity: Cyberevolution and Future Minds*. Charles River Media, 1996.

Pert, Candace. *Molecules of Emotion: Why You Feel the Way You Feel*. Simon and Schuster, 1997.

Peterson, Peter. *Gray Dawn: How the Coming Age Wave Will Transform America—and the World*. Times Books, 1999.

Pickover, Clifford A. *Computers, Pattern, Chaos and Beauty: Graphics from an Unseen World*. New York: St. Martin's Press, 1990.

Pinker, Steven. *The Language Instinct: How the Mind Creates Language*. William Morrow, 1994.

Pritchard, David B. *The Encyclopedia of Chess Variants and Popular Chess Variants*. Games and Puzzles Publications.

Quinn, Daniel. *Ishmael*. Bantam Books, 1995.

Ramachandran, Vilayanur. *Phantoms in the Brain: Probing the Mysteries of the Human Mind*. Morrow, 1998.

Rifkin, Jeremy. *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era.* Putnam, 1995.

Robinson, John P., and Geoffrey C. Godbey. *Time for Life: The Surprising Ways Americans Use Their Time*. Pennsylvania State University Press, 1997.

Rudolph, F., and L. McIntire. *Biotechnology*. Joseph Henry, 1996.

Schor, Juliet. *The Overworked American: The Unexpected Decline of Leisure*. Basic Books, 1991.

Smithsonian Institution. *Forces of Change: A New View of Nature*. With essays by Daniel Botkin, David Quammen, John McPhee, Stephen Jay Gould, Lynn Margulis, and others. Washington, DC: The National Geographic Society, 2000.

Solso, Robert. *Mind and Brain Sciences in the 21st Century*. Cambridge: MIT Press, 1997.

Soros, George. *The Crisis of Global Capitalism: Open Society Endangered*. New York: Public Affairs, 1998.

Stock, Gregory. *Metaman*. Simon and Schuster, 1993.

Stock, Gregory. *Redesigning Humans*. Houghton Mifflin, 2002.

Thorne, Kip S. *Black Holes and Time Warps: Einstein's Outrageous Legacy*. New York: W. W. Norton, 1994.

Walter, Dave. *Today Then: America's Best Minds Look 100 Years into the Future on the Occasion of the 1893 World's Columbian Exposition*. American and World Geographic Publishing, 1992.

Watson, James D. *The Double Helix, A Personal Account of the Discovery of the Structure of DNA*. New York: Scribner, 1968.

Weatherford, Jack. *History of Money*. Three Rivers, 1997.

Weber, Renee. *Dialogues with Scientists and Sages*. Viking Penguin, 1989.

Weinberg, Steven. *The First Three Minutes, A Modern View of the Origin of the Universe*. New York: Basic Books, 1977.

Whitrow, G. J. *What is Time?* London: Thams and Hudson, 1972.

Wilson, Edward O. *On Human Nature*. Harvard University Press, 1978.

Wyke, Alexandra. *Twenty-First Century Miracle Medicine*. Plenum Trade, 1997.

Yergin, Daniel, and Joseph Stanislaw. *The Commanding Heights: The Battle between Government and the Marketplace That Is Remaking the Modern World*. New York: Simon and Schuster, 1998.

Ziman, John. *The Force of Knowledge: The Scientific Dimension of Society*. Cambridge, England: Cambridge University Press, 1976.

Appendix III

Scholar Biographies

W. French Anderson

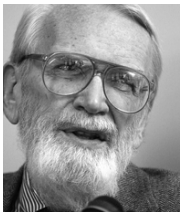
W. French Anderson is the Director of the Gene Therapy Laboratories at the University of Southern California Keck School of Medicine, where he also serves as Professor of biochemistry and pediatrics, is a Full Member of the Norris Comprehensive Cancer Center, and is the Program Coordinator for Gene Therapy in the Institute of Genetics Medicine. Before joining the USC faculty in 1992, he was Chief of the Molecular Hematology Branch at the National Heart, Lung, and Blood Institute at the National Institutes of Health, where he worked as a gene therapy researcher for 27 years. He also served as Chairman of the Department of Medicine and Physiology in the NIH Graduate Program. Dr. Anderson headed the team that carried out the first approved human gene therapy clinical protocol. He is recognized as an ongoing innovator in the research area of human gene transfer, and is also known as a leading ethicist in the field of human genetic engineering. He has been called the "Father of Gene Therapy." The focus of Dr. Anderson's present research is the development of advanced gene therapy delivery systems. Dr. Anderson received an M.D. (*magna cum laude*) from Harvard Medical School. He has published over 300 research articles in leading science and medical journals, and he holds a number of significant patents in the area of human gene therapy.

Athena Andreadis

Athena Andreadis is an academic research scientist examining a fundamental gene regulatory mechanism known as alternative splicing. She is investigating its effects in the central nervous system with the hope that increasing knowledge of this mechanism will contribute to the struggle against mental retardation and dementia. The gene she chose as a model (called tau) causes several types of dementia. Andreadis came to the United States at 18 with a full scholarship to Harvard University. She graduated *magna cum laude* in biochemistry (falling two credits short of a second degree in physics) and proceeded to get her Ph.D. at MIT in molecular biology. After a postdoctoral stint at Harvard Medical, she was appointed Assistant Professor in neurology in 1993. In 1994, she set up her lab at the Shriver Center for Mental Retardation (then a Harvard Medical affiliate, now a part of University of Massachusetts Medical School). Today, she is the Associate Director of the Shriver Center and the head of its basic science division. Dr. Andreadis has explored many ideas about the possibility and forms of life on other planets, the limits of the human body and mind in radically altered environments, and alternative societies. Her book *To Seek Out New Life: The Biology of Star Trek* (Crown, 1998) investigates biology, psychology, and sociology through the lens of the popular eponymous series and films.

John Campbell

John Campbell is Professor of neurobiology at the Geffen School of Medicine and member of the Center for the Study of Evolution and the Origin of Life, University of California, Los Angeles. During his 38 years at UCLA, he has enjoyed repeated visiting appointments at the University of Western Australia; Australian National University; CSIRO, Canberra; the Friday Harbor Marine Laboratories of the University of Washington; and the Mathematics Institute at Oxford. He obtained his bachelor's degree at Caltech, and his doctorate in immunology with A. M. Pappenheimer Jr. at Harvard University. In postdoctoral work, he studied bacterial genetics and enzymology with J. Monod, Institut Pasteur, Paris, and J. Langridge, CSIRO, Canberra. Dr. Campbell was appointed the First Robert Wesson Scholar on Scientific Philosophy and Public Policy, Hoover Institution for War, Peace, and Revolution, Stanford, and he is a Fellow of the AAAS. His research interests center on evolution, genetics, and philosophy. His most pertinent writings on the subject of this conference are book chapters: "The Moral Imperative of Our Future Evolution" and "A Vision for Practical Human Germline Engineering." The former proposes evolutionary principles for projecting a radically rapid future evolution of our lineage. The latter, written with Gregory Stock, describes the current state of our ability to self-direct our genetic improvement. Also, he co-convened a symposium on "Engineering the Human Genome" at UCLA with Gregory Stock and participated in the first workshop of the Center for Human Evolution, Foundation For the Future, in 1998.



Joseph Coates

Joseph Coates is President of Consulting Futurist, Inc., and formerly President of Coates and Jarratt, Inc., a research organization committed exclusively to the study of the future. Since the latter firm's founding in 1979, he has consulted with 45 of the Fortune 100 companies; numerous smaller firms; trade, professional, and public interest groups; and all levels of government. Coates lectures to approximately 50 groups per year about trends and future developments. He is the co-author of *2025: Scenarios of U.S. and Global Society Reshaped by Science and Technology*, *Futurework*, *What Futurists Believe*, and *Issues Management: How You Can Plan, Organize, and Manage for the Future*. He is the author of over 300 articles, chapters, papers, and other publications. Coates was formerly Assistant to the Director and head of exploratory research at the Congressional Office of Technology Assessment. For 20 years he was an Adjunct Professor at George Washington University, where he taught graduate courses on technology and on the future. Earlier, at the National Science Foundation, he was Program Manager of research applied to national needs. His first career was as an industrial chemist at Atlantic Refining Company. He holds 19 patents. He attended Brooklyn Polytechnic Institute, Penn State, and the University of Pennsylvania. He received an honorary doctorate in 1985 from Claremont Graduate School.

Gregory Fowler

Gregory Fowler is the Executive Director of Geneforum, a Portland-based non-profit that promotes public education and civic discourse about ethical and social issues raised by new genetic technologies. Partnering with individuals and organizations at the local, state, and national levels, Geneforum creates active learning environments, using discussion for exploring values in high school classroom visits, teacher workshops, town hall meetings, public opinion research, publication, talk-radio, and an interactive website with an online newsletter (http://www.geneforum.org). Dr. Fowler has published numerous articles and essays including one of the first to suggest new directions for the professional discussion of germline gene therapy. His more recent writings—including a chapter in *Genes and Morality: New Essays* [Rodopi, 1999]: "Translating the Human Genome Project into Social Policy"—describe the Geneforum model for linking public values to the genetic policy process. He is a standing member of the Oregon Legislature's Advisory Committee on Genetic Privacy and Research, and Oregon's only Fellow of the World Academy of Art and Science. He was formerly a Fellow in the Science and Engineering Diplomacy Program of the American Association for the Advancement of Science, and received an Ethics and Values in Science and Technology Individual Award from the National Science Foundation and the National Endowment for the Humanities to study the social and ethical implications of genetic engineering. He is presently an Oregon Chautauqua Scholar of the Oregon Council for the Humanities, for which he travels to communities throughout Oregon to dialogue with citizens on the implications of contemporary genetic research. He holds a doctorate in genetics from Brown University and is Clinical Associate Professor in the Department of Public Health and Preventive Medicine, Oregon Health and Sciences University, Portland.

James J. Hughes

James J. Hughes teaches health policy at Trinity College in Hartford, Connecticut, and has taught medical sociology, bioethics, and health policy at the University of Chicago, Northwestern University, and the University of Connecticut. From 1991 to 1995 he taught at the MacLean Center for Clinical Medical Ethics at the University of Chicago where he served as the Assistant Director of Research. Dr. Hughes received his sociology doctorate from the University of Chicago in 1994 for work on the effects of managed care and expert systems on the division of labor in medicine. He has published widely on bioethics, health policy, politics, and Buddhism (he is a former Buddhist monk). He is a member of the Working Group on Artificial Intelligence, Nanotechnology, and Transhumanism based at Yale University's Institute for Social and Policy Studies, and the International Network for the Definition of Death, an affiliate of the International Association of Bioethics. Dr. Hughes has founded and edited two periodicals, the *EcoSocialist Review* and *Doctor-Patient Studies.* Since 1998, he has produced a weekly syndicated radio program, *Changesurfer Radio*, which focuses on the political issues raised by future technologies. In 2002, Dr. Hughes was elected Secretary of the World Transhumanist Association. In that capacity he is Conference Chair of Transvision 2003 USA, the first conference ever held on transhumanist bioethics (June 27–29, 2003, Yale University).

Gregory Stock

Gregory Stock is the Director of the Program on Medicine, Technology, and Society at UCLA's School of Public Health. In this role he explores critical technologies poised to have large impacts on humanity's future and the shape of medical science. His goal has been to bring about a broad public debate on these technologies and their implications, leading to wise public policies surrounding their realization. Of particular interest to the program are the implications of the Human Genome Project and associated developments emerging from today's revolution in molecular genetics and bioinformatics. In 1998, he initiated the first major public discussion among distinguished scientists of the possibilities of manipulating the genetics of human embryos, opening a global debate on this then-taboo topic. The Storefront Genome, the symposium he convened in January 2003, considered the broad challenges that cheap, easy access to our genetic constitutions will bring. Dr. Stock's 2002 book, *Redesigning Humans: Our Inevitable Genetic Future*, won the first Walter P. Kistler Book Award and was nominated for a WIRED Rave Award. Among his other books are *Engineering the Human Germline*, *Metaman*, and the bestseller *The Book of Questions*, which has been translated into 17 languages, and is now in its 55th printing. Sequels include *The Book of Questions: Business, Politics, and Ethics* and a new book that will explore how coming technologies will reshape our everyday lives. Dr. Stock has been an invited speaker at numerous academic, government, and business conferences, sits on the editorial board of the *American Journal of Bioethics*, and was asked to submit an Advisory Memo to the US President on the challenges of the next century. He makes regular appearances on television and radio, including CNN, PBS, NPR, Bloomberg, and the BBC, and he is hosting a television special in 2003 on key figures in today's biotech revolution. He has a doctorate in biophysics from Johns Hopkins University and an MBA from Harvard University, and he currently has appointments at Princeton University and UCLA's School of Public Health.

Jeffry Stock

Jeffry Stock was born in Los Angeles and went to college in Baltimore at Johns Hopkins, where he received a B.A. in biophysics (1967) and a Ph.D. in biochemistry (1975). His thesis work provided an important contribution to our understanding of bioenergetics, helping establish the "chemiosmotic theory" for which Peter Mitchell eventually won the Nobel Prize. Dr. Stock then took a postdoctoral fellowship at Berkeley where he began to investigate fundamental molecular mechanisms of cell regulation using bacteria as model organisms. He continued these studies at Princeton where he started as an Assistant Professor in 1982, working his way through the ranks to Full Professor in molecular biology and chemistry, his current position. The bacterial work established the major mechanism of receptor-mediated signal transduction in micro-organisms and plants—the so-called two-component sensor kinase/response regulator systems. At Princeton he initiated biochemical studies of signal transduction in vertebrate tissues, most notably the brain. This work led to the discovery of global regulatory protein methylation reactions that operate in signal transduction by controlling G-protein-mediated receptor signaling and protein phosphorylation. Recent work in his laboratory has begun to focus on the implications of these findings for human health. Many chronic diseases show evidence of a methylation component, including atherosclerosis, Alzheimer's, Parkinson's, stroke, schizophrenia, bipolar disorder, diabetes, and arthritis. These studies have led to a novel theory to explain the etiology of Alzheimer's. In addition to basic research, Dr. Stock has been involved in biotechnology and has been a founder of two companies: Cadus Pharmaceuticals (Kdus) and just recently a new startup, Signum Biosciences.

Burke Zimmerman

Burke K. Zimmerman received his formal training in physics and biophysics (B.A., Harvard; Ph.D., Stanford), and was a research scientist in his early career (Oak Ridge National Laboratory, Johns Hopkins University School of Medicine, Baltimore). Beginning in the late 1970s, he held key science policy positions with the US Congress and NIH before joining a leading biotechnology company in 1982 (Cetus Corporation). Throughout the 1980s, he was a consultant to and served in executive roles for several international biotechnology initiatives, especially those designed to bring biotechnology to bear on the problems of the lesser-developed regions of the world. Except for a one-year visiting professorship at the University of California (San Francisco and Berkeley), he lived in Europe from 1985 to 1999. During the latter part of this period, he founded and directed an innovative research company in Finland specializing in the design and development of novel vaccines and immunotherapeutics. He currently lives in Oakland, California, where he is President and Chairman of BKZ Inc., specializing in immunology. He also provides independent consulting. Dr. Zimmerman is the author of numerous articles, book chapters, and research papers dealing with a broad range of issues in science policy and bioethics. His book *Biofuture: Confronting the Genetic Era* (New York: Plenum Press, 1984, foreword by Francis Crick) reviews for the general reader the extraordinary advancements in the biological sciences since 1970, and analyzes and discusses "controversial" science and technology, the philosophy of discovery and determinism in science, as well as man's (in)ability to anticipate the future. Nevertheless, he dares to speculate on the directions in which this continuing revolution will lead us in the years to come.

Appendix IV

Producer and Affiliate Biographies

Jon Palfreman

Jon Palfreman is President of Palfreman Film Group, Lowell, MA. Following graduation from University College, London, with first class honors in physics, he went on to earn an M.Sc. at Sussex University in history and philosophy of science. He worked as a lecturer before joining BBC Television, where he produced dozens of programs about science, technology, and medicine. In the late 1980s, Palfreman relocated to Boston to work at WGBH, where he produced the NOVA miniseries *The Pioneers of Surgery* and the Peabody Award-winning series *The Machine That Changed the World*. More recently, Palfreman's programs for *Frontline* and NOVA have explored the intersection of science, policy, and law. Palfreman has made more than one hundred television programs, including over 40 PBS documentaries such as the Emmy Award-winning NOVA "Siamese Twins." He is a three-time winner of the AAAS/Westinghouse Science Journalism Award for NOVA, and has received the National Association of Science Writers "Science-in-Society Journalism Award," the American Medical Association's "Women's Health Award," the 2001 Victor Cohn Prize for Excellence in Medical Science Reporting, and the Alfred I. duPont-Columbia University Silver Baton for Outstanding Television News. He is the author of two books and an Adjunct Professor at Tufts University. In 1996, Palfreman established Palfreman Film Group, which specializes in high-end science programs for PBS.

Barbara Moran

Barbara Moran is a Producer with Palfreman Film Group. She holds a B.A. in American studies from the University of Notre Dame and an M.S. in science journalism from Boston University. She has worked in television production since 1995. Moran earned her first national credits as an Associate Producer on the Discovery Channel science series *Discover Magazine*, where she was entrenched in the research, writing, and field production on location throughout North America and Europe for five one-hour programs. After leaving *Discover Magazine*, she co-produced and co-wrote a one-hour documentary, "The Wizard of Photography," about George Eastman and the rise of popular photography, for PBS's premiere historical documentary series, *American Experience*. Moran has also produced, written, and directed documentaries for The History Channel and the Discovery Channel Health Network, as well as an independent documentary, "Big Man Run." In addition, Moran is a prolific freelance writer specializing in the history of science and technology. Her writing has appeared in *Technology Review*, *The Boston Globe*, *New Scientist*, and *American Heritage of Invention and Technology*. She was a Knight Science Journalism Fellow at MIT in 2001–02 and a Science Writing Fellow at the Marine Biological Laboratory in 1999.

Kirk Citron

Kirk Citron, an award-winning writer and advertising entrepreneur, is Chief Strategic Officer of AKQA, San Francisco. In 1990, he founded Citron Haligman Bedecarré, the fastest-growing advertising agency in the United States for 1999–2000. In 2001, he raised $71 million in venture capital, bought agencies in London, Singapore, and Washington DC, and changed the name of the company to AKQA. His agency has created advertising for Nike, Visa, Microsoft, Palm, The Gap, Dreyfus, Macy's, and Kenwood, and has been written about in *The New York Times*, *The Wall Street Journal*, *Los Angeles Times*, *San Francisco Chronicle*, and the advertising press (including a cover story in *Communication Arts Magazine*). He has also written for *Adweek*, *Advertising Age*, and *Graphis*. In 1996, *Adweek* named the agency West Agency of the Year; *Advertising Age* creativity magazine included his firm on a list of the 17 most creative agencies in the country. Citron graduated in 1977 from Harvard, where he studied anthropology and film. At Ogilvy & Mather, New York, he was the youngest Vice President in the agency's history. At Hal Riney & Partners, San Francisco, he wrote the theme line for Saturn automobiles: "A different kind of company. A different kind of car." Citron has been inducted into the American Advertising Federation's Hall of Achievement, and he has won five Clios. He has lived in San Francisco, New York, Seattle, Boston, Los Angeles, Oslo, Addis Ababa, and Johannesburg, and lives today in Mill Valley, California.

Anna Reid Jhirad

Anna Reid Jhirad, founder and President of Marigold Productions, Washington, DC, is an award-winning writer/producer with more than 20 years of experience in television and radio programming. Her films have appeared on commercial and public broadcasting networks, in educational markets, and in museums. They include major specials and multimillion-dollar series for national television in a wide range of fields: science, art, biography, history, literature, race relations, and current affairs. These have won significant awards: Academy Award nominee for *A Place in the Land*, which was co-written with Charles Guggenheim and which airs daily at the Billings Museum in Woodstock, Vermont; three local Emmys and an Emmy nominee for writing for *Impressionists on the Seine*; an International Cine and the Jade Award for Technical Excellence in Writing for *Kate Chopin: A Re-Awakening*; an Arbor Day Foundation Award as Best Environmental Documentary for *The Forest Where We Live*. She is currently the project director, producer, and writer of *Great American Places: The South*, a four-part series on the cultural history of the South, and co-producer/writer of *Reaching for the Light,* a television program on homeless children. As a freelance writer, she is currently developing four IMAX films on scientific stories. She has been a writer on numerous films and television programs, among which are *Louisiana, A History*; *Guns, Germs, and Steel*, which she co-wrote with David Grubin for National Geographic, and *Rescue*, a one-hour program for international broadcast on the 1943 rescue of Danish Jews. Jhirad has also written proposals, treatments, and scripts for WNET for several shows including *Hispanics*, a six-part series.

Appendix V

Selected Bibliographies of Participating Scholars

Anderson, W. F. (2002). Editorial: "The Current Status of Clinical Gene Therapy." *Hum. Gene Ther., 13*: 1261–1262.

Anderson, W. F. (2001). Editorial: "Excitement in Gene Therapy." *Hum. Gene Ther., 12*:1483–1484.

Anderson, W. F. (2000). "Gene Therapy Scores against Cancer." *Nature Medicine, 6*: 862–863.

Anderson, W. F. (2000). "A New Front in the Battle against Disease." In Gregory B. Stock and John Campbell (Eds.) *Engineering the Human Germline*. New York: Oxford Univ. Press, 43–48.

Anderson, W. F. (2000). "A Cure That May Cost Us Ourselves." *Newsweek*, (January 1): 74–76.

Anderson, W. F. (1999). "Gene Therapies." In Sian Griffiths (Ed.) *Predictions: 30 Great Minds on the Future*. The Times Higher Education Supplement. New York: Oxford University Press, 19–21.

Zanjani, E., and **W. F. Anderson** (1999). "Prospects for *In Utero* Human Gene Therapy." *Science*, *285:* 2084–2088.

Anderson, W. F., and N. Wivel (1999). "Human Gene Therapy: Public Policy and Regulatory Issues." In Theodore Friedmann (Ed.) *The Development of Gene Therapy*. New York: Cold Spring Harbor Laboratory Press, 671–689.

Anderson, W. F. (1998). "Human Gene Therapy." *Nature, 392* [SUPP]: 25–30.

Anderson, W. F. (1997). "Human Gene Therapy: The Initial Concepts." In K. L. Brigham (Ed.) *Gene Therapy for Diseases of the Lungs*, Marcel Dekker, Inc., 3–16.

Polvino, W. J., and **W. F. Anderson** (1996). "Medicine, Gene Therapy, and Society." In T. Murray, M. Rothstein, and R. Murray (Eds.) *The Human Genome Project and the Future of Health Care*. Indiana University Press, 39–57.

Anderson, W. F. (1995). "Gene Therapy." *Sci. Amer. 273*: 124–128.

Anderson, W. F. (1994). "Genetic Engineering and Our Humanness." *Hum. Gene Ther., 5*: 755–760.

Blaese, R. M., K. W. Culver, A. D. Miller, and **W. F. Anderson** (1993). "Gene Therapy for Immunodeficiency and Cancer." *Prog. in Immunol., VIII*: 553–555.

Morgan, R. A., and **W. F. Anderson** (1993). "Human Gene Therapy." *Helix, 2*: 26–35.

Anderson, W. F. (1992). "Genetic Engineering and Our Humanness." *Cathedral Papers, 4*: 27–43.

Fletcher, J. C., and **W. F. Anderson** (1992). "Germ-line Gene Therapy: A New Stage of Debate." *Law, Medicine, and Health Care, 20*: 26–39.

Karson, E. M., W. Polvino, and **W. F. Anderson** (1992). "Prospects for Human Gene Therapy." *J. Reprod. Med., 37*: 508–514.

Culver, K. W., R. M. Blaese, and **W. F. Anderson** (1992). "Gene Therapy: A New Frontier in Medicine." In D. Calhoun and C. Cegielski (Eds.) *Yearbook of Science and the Future*. Chicago: Encyclopedia Britannica, Inc., 126–137.

Anderson, W. F. (1992). "Human Gene Therapy." *Science, 256*: 808–813.

Anderson, W. F. (1992). Editorial: "Uses and Abuses of Human Gene Transfer." *Hum. Gene Ther., 3*: 1–2.

Anderson, W. F. (1991). "Expectations from Recombinant DNA Research." In J. B. Wyngaarden, L. H. Smith, and W. H. Bennett (Eds.) *Cecil Textbook of Medicine*, 19th edition. Philadelphia: W. B. Saunders Co., 130–133.

Morgan, R. A., and **W. F. Anderson** (1991). "Gene Therapy for AIDS." In A. Kumar (Ed.) *Advances in Molecular Biology and Targeted Treatment for AIDS*. New York: Plenum Press, 301–308.

Cornetta, K., R. A. Morgan, and **W. F. Anderson** (1991). "Safety Issues Related to Retroviral-mediated Gene Transfer in Humans." *Hum. Gene Ther., 2*: 5–14.

Anderson, W. F., and K. B. Wadhams (1991). "Genetic Engineering." In *McGraw-Hill Yearbook of Science and Technology*. New York: McGraw-Hill, Inc., 158–159.

Anderson, W. F. (1990). "Genetics and Human Malleability." *The Hastings Center Report, 20*: 21–24.

Karson, E., and **W. F. Anderson** (1990). "Prospect for Gene Therapy in the Perinatal Patient." In M. R. Harrison, M. S. Golbus, and R. A. Filly (Eds.) *The Unborn Patient: Prenatal Diagnosis and Treatment*. New York: Grune and Stratton, 481–494.

Thompson, J. A., T. Maciag, C. C. Haudenschild, K. D. Anderson, J. M. DiPietro, and **W. F. Anderson** (1989). "Implantable Bioreactors: Modern Concepts of Gene Therapy." In D. Marshak and D. Liv (Eds.) *Communications in Molecular Biology*. New York: Cold Spring Harbor, 143–147.

Anderson, W. F. (1989). "Human Gene Therapy: Why Draw a Line?" *J. Med. and Phil., 14*: 681–693.

Kohn, D. B., **W. F. Anderson**, and R. M. Blaese (1989). "Gene Therapy for Genetic Diseases." *Cancer Invest., 7*: 179–192.

Zanjani, E. D., P. W. Kantoff, D. Ekhterae, S. Bond, L. C. Lasky, M. R. Harrison, and **W. F. Anderson** (1988). "Approaches to Gene Therapy." In *Clinical Applications of Genetic Engineering*, Amer. Assoc. Blood Banks Publication, 47–57.

Kantoff, P.W., S. M. Freeman, and **W. F. Anderson** (1988). "Prospects for Gene Therapy for Immunodeficiency Diseases." *Ann. Rev. Immunol., 6*: 581–94.

Anderson, W. F. (1986). "Prospects for Human Gene Therapy in the Born and Unborn Patient." *Clin. Obst. Gyn., 29*: 586–594.

Anderson, W. F. (1985). "Beating Nature's Odds." *Science, 85*: 49–50.

Anderson, W. F. (1985). "Human Gene Therapy: Scientific and Ethical Considerations." *J. Med. and Phil., 10*: 275–291.

Anderson, W. F. (1984). "Prospects for Human Gene Therapy." *Science, 226*: 401–409.

Anderson, W. F. (1981). "Gene Therapy" (Bench and Bedside Series). *JAMA, 246*: 2737–2739.

Anderson, W. F., and E. G. Diacumakos (1981). "Genetic Engineering in Mammalian Cells." *Scientific American, 245*: 106–121.

Anderson, W. F., P. J. Kretschmer, L. Sanders-Haigh, L. Killos, and E. G. Diacumakos (1981). "Gene Transfer and *In Vitro* Expression." In G. Stamatoyannopoulos and A. W. Nienhuis (Eds.) *Organization and Expression of Globin Genes*. New York: Alan R. Liss, Inc., 301–312.

Anderson, W. F., and J. C. Fletcher (1980). "Gene Therapy in Human Beings: When Is It Ethical to Begin?" *New England Journal of Medicine, 303*: 1293–1297.

Velez, R., J. A. Kantor, A. W. Steggles, G. N. Wilson, **W. F. Anderson**, and A. W. Nienhuis (1975). "*In Vitro* Transcription of Human Globin Genes." In J. I. Hercules, A. N. Schechter, W. A. Eaton, and R. E. Jackson (Eds.) *Proceedings of the First National Symposium on Sickle Cell Disease*. DHEW Publ. No. (NIH) 75–723, pp. 177–178.

Anderson, W. F. (1973). "Eugenic Policy and Hard Decisions." In P. Wogaman (Ed.) *The Population Crisis and Moral Responsibility*. Washington, DC: Public Affairs Press, 270–273.

Anderson, W. F. (1972). "Genetic therapy." In M. Hamilton (Ed.) *The New Genetics and the Future of Man*. Grand Rapids, MI: William B. Eerdmans, Publisher, 109–124.

Conrad, C., **A. Andreadis**, J. O. Trojanowski, D. W. Dickson, D. Kang, X. Chen, W. Wiederholt, L. Hansen, E. Masliah, L. Thal, R. Katzman, Y. Xia, and T. Saitoh (1996). "Genetic Evidence for the Etiological Involvement of Tau in Progressive Supranuclear Palsy." *Ann. Neurol.*, *41*: 277–281.

Froehlich, S., H. Basun, C. Forsell, L. Lilius, K. Axelman, **A. Andreadis**, and L. Lannfelt (1997). "Mapping of a Disease Locus for Familial Rapidly Progressive Frontotemporal Dementia to Chromosome 17q12-21." *Am. J. Med. Genet.*, *74*: 380–385.

Baker, M., J. Kwok, S. Kucera, R. Crook, H. Houlden, A. Isaacs, S. Lincoln, J. Hardy, L. Wittenberg, P. Dodd, S. Webb, N. Hayward, T. Tanneberg, **A. Andreadis**, M. Hallupp, P. Schofield, F. Dark, and M. Hutton (1997). "Localization of Fronto-Temporal Dementia with Parkinsonism in an Australian Kindred to Chromosome 17q21-22." *Ann. Neurol.*, *42*: 794–798.

Poorkaj, P., T. D. Bird, E. Wijsman, E. Nemens, R. M. Garruto, L. Anderson, **A. Andreadis**, W. Wiederholt, M. Raskind, and G. Schellenberg (1998). "Tau Is a Candidate Gene for Chromosome 17 Frontotemporal Dementia." *Ann. Neurol.*, *43*: 815–825.

Hutton, M., C. L. Lendon, P. Rizzu, M. Baker, S. Froelich, H. Houlden, S. Pickering-Brown, S. Chakraverty, A. Isaacs, A. Grover, J. Hackett, J. Adamson, S. Lincoln, D. Dickson, P. Davies, R. C. Petersen, M. Stevens, E. de Graaff, E. Wauters, J. van Baren, M. Hillebrand, M. Joosse, J. M. Kwon, P. Nowotny, L. K. Che, J. Norton, J. C. Morris, L. A. Reed, J. Trojanowski, H. Basun, L. Lannfelt, M. Neystat, S. Fahn, F. Dark, T. Tannenberg, P. Dodd, N. Hayward, J. B. J. Kwok, P. R. Schofield, **A. Andreadis**, J. Snowden, D. Craufurd, D. Neary, F. Owen, B. A. Oostra, J. Hardy, A. Goate, J. van Swieten, D. Mann, T. Lynch, and P. Heutink (1998). "Association of Missense and 5' Splice Site Mutations in Tau with the Inherited Dementia FTDP-17." *Nature*, *393*: 702–705.

Conrad, C., N. Amano, **A. Andreadis**, Y. Xia, K. Namekata, F. Oyama, K. Ikeda, K. Wakabayashi, H. Takahashi, L. J. Thal, R. Katzman, D. A. Shackelford, M. Matshushita, E. Masliah, and A. Sawa (1998). "Differences in a Dinucleotide Repeat Polymorphism in the Tau Gene between Caucasian and Japanese Populations; Implications for Progressive Supranuclear Palsy." *Neurosci. Lett., 250*:135–137.

Clark, L. N., P. Poorkaj, Z. Wszolek, D. H. Geschwind, Z. S. Nasreddine, B. Miller, D. Li, H. Payami, F. Awert, K. Markopoulou, **A. Andreadis**, I. D'Souza, V. M. Y. Lee, L. Reed, J. Q. Trojanowski, V. Zhukareva, T. Bird, G. Schellenberg, and K. Wilhelmsen (1988). "Pathogenic Implications of Mutations in the Tau Gene in Pallido-Ponto-Nigral Degeneration and Related Neurodegenerative Disorders Linked to Chromosome 17." *Proc. Natl. Acad. Sci., 95*: 13103–13107.

Lilius, L., S. Froehlich, S. Basun, C. Forsell, K. Axelman, K. Matilla, **A. Andreadis**, M. Viitanen, B. Winblad, L. Fratiglioni, and L. Lannfelt (1999). "Tau Gene Polymorphisms Interact with Apolipoprotein E e4 to Increase Risk for Familial Alzheimer's Disease." *Neurosci. Lett., 277*: 29–32.

Mathews, P. M., A. M. Cataldo, B. H. Kao, A. G. Rudnicki, X. Qin, J. L. Yang, Y. Jiang, M. Picciano, C. Hulette, K. Dole, C. F. Lippa, T. D. Bird, D. Nochlin, J. Walter, C. Haass, L. Levesque, P. E. Fraser, **A. Andreadis**, and R. A. Nixon (2000). "Brain Expression of Presenilins in Sporadic and Early-Onset, Familial Alzheimer's Disease." *Mol. Med., 6*: 878–91.

Breitbart, R. E., **A. Andreadis**, and B. Nadal-Ginard (1987). "Alternative Splicing: A Ubiquitous Mechanism for the Generation of Multiple Protein Isoforms from a Single Gene." *Ann. Rev. Biochem, 56*: 467–495.

Andreadis, A., M. E. Gallego, and B. Nadal-Ginard (1987). "Generation of Protein Diversity by Alternative Splicing: Mechanism and Biological Implications." *Ann. Rev. Cell Biol, 3*: 207–242.

Nadal-Ginard, B., **A. Andreadis**, and M. E. Gallego (1987). "Alternative Splicing: Mechanistic and Biological Implications of Generating Multiple Proteins from a Single Gene." *Genetic Engineering, 9*: 249–280.

Dräger, U. C., E. Wagner, **A. Andreadis**, and P. McCaffery (1998). "The Role and Evolutionary Development of Retinoic-Acid Signaling in the Eye." In M. A. Livrea (Ed.) *Vitamin A and Retinoids: An Update of Biological Aspects and Clinical Applications*. Birkhäuser Publishing Ltd., 73–82.

Andreadis, A. (1998). *To Seek Out New Life: The Biology of Star Trek*. New York: Crown Publishing Group.

Andreadis, A. (1998)."Eyes to the Skies." *Harvard Medical School Alumni Bulletin*, (April).

Andreadis, A. (1998). "Space and Spirit." *MS-NBC Online*, (June).

Andreadis, A. (1998). "Good Planets Are Hard to Find." *Astronomy Magazine*, (December).

Andreadis, A. (1999). "Let Me Set Sail for Open Water." *Eleftherotypia*, (February).

Andreadis, A. (2000). "E. T., Call Springer-Verlag!" *SETI League*, (August).

Andreadis, A. (2000). "Can We Colonize Rigel IV?" *Zenit Magazine*, (September).

Campbell, J. H., and A. M. Pappenhemeir Jr. (1963). "Comparison between the Specificity of Antibodies to Pneumococcal Polysaccharides S3 and S8 and the Induced S3 and S8 Depolymerases of Bacillus Palustris." *Ann. N.Y Acad Sci., 103*: 1014–1024.

Campbell, J. H., and A. M. Pappenheimer Jr. (1966). "Quantitative Studies of the Specificity of Anti-Pneumococcal Polysaccharide Antibodies, Types III and VIII–I. Isolation of Oligosaccharides from Acid and from Enzymatic Hydrolysates of S3 and S8." *Immunochemistry, 3*: 195–212.

Campbell, J. H., and A. M. Pappenheimer Jr. (1966). "Quantitative Studies of the Specificity of Anti-Pneumococcal Polysaccharide Antibodies, Types III and VIII–II. Inhibition of Precipitin Reactions with Oligosaccharides Isolated from Hydrolysates of S3 and S8." *Immunochemistry, 3*: 213–222.

Campbell, J. H. (1967). "Permissive Translation of Nucleic Acid: A Mechanism for Antibody Synthesis." *J. Theoret. Biol., 16*: 321–331.

Langridge, J., and **J. H. Campbell** (1969). "Classification and Intragenic Position of Mutations in the Beta-Galactosidase Gene of Escherichia Coli." *Mol. Gen. Genet., 103*: 339–347.

Campbell, R. D., and **J. H. Campbell** (1971). "Origin and Continuity of Desmosomes." In H. Uhrsprung (Ed.) *Origin and Continuity of Cell Organelles, Vol. 3*, Berlin: Springer-Verlag, 261–298.

Campbell, J. H., J. Levy, and J. Langridge (1973). "Evolution of a Second Gene for Beta-Galactosidase in Escherichia Coli." *Proc. Natl. Acad. Sci. USA, 70*: 1841–1845.

Rolfe, B. G., and **J. H. Campbell** (1974). "A Relationship between Tolerance to Colicin K and the Mechanisms of Phage-Induced Host Cell Lysis." *Molec. Gen. Genet., 133*: 293–297.

Campbell, J. H., and B. G. Rolfe (1975). "Evidence for a Dual Control of the Initiation of Host-Cell Lysis Caused by Phage Lambda." *Molec. Gen. Genet., 139*: 1–8.

Arraj, J., and **J. H. Campbell** (1975). "Isolation and Characterization of the Newly Evolved ebg Beta-Galactosidase of Escherichia Coli K12." *J. Bacteriol., 124*: 849–856.

Hood, L., **J. H. Campbell**, and S. C. R. Elgin (1975). "The Organization, Expression and Evolution of Antibody Genes and Other Multigene Families." *Ann. Rev. Genet., 9*: 305–353.

Rolfe, B. G., and **J. H. Campbell** (1977). "Genetic and Physiological Control of Host Cell Lysis by Bacteriophage Lambda." *J. Virol., 23*: 626–636.

Dykhuizen, D., **J. H. Campbell**, and B. G. Rolfe (1978). "The Influences of a Lambda Prophage on the Growth Rate of Escherichia Coli." *Microbios, 23*: 99–113.

Campbell, J. H., D. Dykhuizen, and B. G. Rolfe (1979). "Effects of the Rex Gene of Phage Lambda on Lysogeny." *Genet. Res. Camb., 32*: 257–263.

Campbell, J. H., and E. Zimmermann (1982). "Auto-Modulation of Genes: A Proposed Mechanism for Persisting Effects of Drugs and Hormones in Mammals." *Neurobehav. Toxic. Terat., 4*: 435–113.

Campbell, J. H. (1982). "Autonomy in Evolution." In R. Milkman (Ed.) *Perspectives on Evolution*. Sunderland: Sinauer Assoc., 190–200.

Hunkapiller, T., H. Huang., L. Hood, and **J. H. Campbell** (1982). "The Impact of Modern Genetics on Evolutionary Theory." In R. Milkman (Ed.) *Perspectives on Evolution*. Sunderland: Sinauer Assoc., 164–189.

Campbell, J. H. (1983). "Evolving Concepts of Multigene Families." *Curr. Top. Biol. Med. Res., 10*: 401–417.

Campbell, J. H. (1985). "An Organizational Interpretation of Evolution." In D. J. Depew and B. H. Weber (Eds.) *Evolution at a Crossroads: The New Biology and the New Philosophy of Science*. Cambridge: MIT Press.

Maynard Smith, J., R. Burian, S. Kauffman, P. Alberch, **J. Campbell**, B. Goodwin, R. Lande, D. Raup, and L. Wolpert (1985). "Developmental Constraints on Evolution." *Quart. Rev. Biol., 60*: 265–287.

Ermentrout, B., **J. Campbell**, and G. Oster (1986). "A Model for Shell Patterns Based on Neural Activity." *Veliger, 28*: 369–388.

Campbell, J. H. (1987). "The New Gene and Its Evolution." In K. S. W. Campbell and M. Day (Eds.) *Rates of Evolution*. London: Allen & Unwin, 283–309.

Campbell, J. H. (1987). "Evolution as Nonequilibrium Thermodynamics: Halfway There?" In B. H. Weber, D. J. Depew, and J. D. Smith (Eds.) *Information, Time and Evolution*. Cambridge: MIT Press, 275–284.

Campbell, J. H., and P. Perkins (1988). "Transgenerational Effects of Drug and Hormonal Treatments in Mammals: A Review of Observations and Ideas." *Prog. Brain Res., 73*: 535–553.

Campbell, J. H. (1989). "Metadarwinism." *Proc. 33rd Ann. ISSS, 3*: 56–61.

Campbell, J. H. (1991). "An RNA-Replisome as the Ancestor of the Ribosome." *J. Molec. Evol., 32*: 3–5.

Campbell, J. H. (1991). "Transgenerational Effects of Drugs and Their Interpretation: The Cybernin System." In T. Fujii and G. J. Boar (Eds.) *Functional Neuroteratology of Short-term Exposure to Drugs*, 5–21.

Campbell, J. H. (1993). "A Tilt at Cladism or Let's Contemplate Evolution Instead of Our Belly Buttons." *Mem. Ass. Australas. Paleontols, 15*: 43–50.

Campbell, J. H. (1994). "Organisms Create Evolution." In **J. H. Campbell** and J. W. Schopf (Eds.) *Creative Evolution?!* Boston: Jones and Bartlett Press, 85–102.

Campbell, J. H. (1995). "The Moral Imperative of Man's Future Evolution." In R. Wesson and P. Williams (Eds.) *Evolutionary Journeys.* Amsterdam: Rodopi Press, 79–114.

Campbell, J. H. (1995). "*Homo Sapiens* K12." *Australasian. Soc. Hum. Biol., 7*: 9–14.

Stock, G. B., and **J. H. Campbell** (1966). "Human Society as an Evolving Superorganism: A Biological Perspective." In K. Boulding and E. Khalil (Eds.) *Evolution Order and Complexity*. London: Routledge, 181–198.

Campbell, J. H., and G. B. Stock (2000). "A Vision for Practical Human Germline Engineering." In Gregory Stock and **John Campbell** (Eds.) *Engineering the Human Germline: An Exploration of the Science and Ethics of Altering the Genes We Pass to Our Children*. Oxford University Press, 9–16.

Stock, G. B., and **J. H. Campbell** (2000). "Introduction: An Evolutionary Perspective." In Gregory Stock and **John Campbell** (Eds.) *Engineering the Human Germline: An Exploration of the Science and Ethics of Altering the Genes We Pass to Our Children*. Oxford University Press, 3–6.

Campbell, J. H. (2000). "Principles Behind the Future of Human Intelligence." In *Evolution of Human Intelligence*, Foundation For the Future, 45–60.

Campbell, J. H., and J. W. Schopf (Eds.) (1994). *Creative Evolution?!* Boston: Jones and Bartlett.

Gregory Stock and **John Campbell** (Eds.) (2000). *Engineering the Human Germline: An Exploration of the Science and Ethics of Altering the Genes We Pass to Our Children*. Oxford University Press.

Coates, Joseph F., and John B. Mahaffie (1997). *2025: Scenarios of U.S. and Global Society Reshaped by Science and Technology.* Oakhill Press.

Coates, Joseph F., and Jennifer Jarratt (1994). *Managing Your Future as an Association: Thinking about Trends and Working with Their Consequences, 1993–2020*. American Society of Association Executives.

Jarratt, Jennifer, and **Joseph F. Coates** (Eds.) (1992). *The Future: Trends into the Twenty-First Century*. SAGE Publications.

Coates, Joseph F., Jennifer Jarratt, and John B. Mahaffie (1990). *Future Work: Seven Critical Forces Reshaping Work and the Work Force in North America*. Jossey-Bass Inc., Publishers.

Coates, Joseph F., Jennifer Jarratt (1989). *What Futurists Believe*. Lomond Publications, Inc.

Coates, Joseph F. (1986). *Issues and Management: How to Plan, Organize, and Manage for the Future*. Lomond Publications Inc.

Coates, Joseph F. (Guest Editor) (2001). *The Future as a Factor in Business Planning and Management,* Special Issue of *Futures Research Quarterly, 17* (3) (Fall).

Coates, Joseph F. (Columnist). *Technological Forecasting and Social Change*.

Coates, Joseph F. (Columnist). *Research–Technology Management*.

Coates, Joseph F. (Columnist). *Employment Relations Today*.

Coates, Joseph F., (2002). "Four Perspectives on the Future of Work." *Employment Relations Today*, (Spring).

Coates, Joseph F. (2001). "Technology and the Changing City." *Journal of Urban Technology, 8* (2) (August): 95–106.

Coates, Joseph F. (2001). "A 21st Century Agenda for Science and Technology Policy." *Research–Technology Management*, (September-October).

Coates, Joseph F. (2000). "Treatment of Disease in the 21st Century." In *Vital Speeches of the Day, LXVI* (9) (February 15).

Coates, Joseph F. (2000). "Culture and the Selection of Techniques for Exploring the Future," *Journal of Futures Studies, 5* (2) (November): 171–178.

Coates, Joseph F. (1999). "Review of *The Giant Leap: Mankind Heads for the Stars* by Adrian Berry." *Interdisciplinary Science Reviews, 24* (4).

Coates, Joseph, F. (1999). "Thinking About Humanity in the Year 3000." *Futures Research Quarterly* (Winter).

Coates, Joseph F. (1999). "Getting at Assumptions Is Troublesome," *Technological Forecasting and Social Change, 62*: 97–99.

Coates, Joseph F., John B. Mahaffie, and Andy Hines (1999). "2025: Scenarios of US and Global Society Reshaped by Science and Technology." *Foresight, the Journal of Futures Studies, Strategic Thinking and Policy, 1* (2) (April).

Coates, Joseph F. (1999). "Looking Ahead: The Inevitability of Knowledge Management." *Research–Technology Management*, (July–August).

Coates, Joseph F. (1999). "Wild Ideas in Future Cities." *The Bridge*, 29 (4) (Winter).

Coates, Joseph F., John B. Mahaffie, and Andy Hines (1998). "The Promise of Genetics." *The Futurist*, World Future Society, (January–February).

Coates, Joseph F. (1998). "The Future of Heroism." *Technological Forecasting and Social Change, 59*: 305–308.

Coates, Joseph F. (1998). "How to Think Like a Futurist." Proceedings from the Heinz Nixdorf Institute, Second Paderborn Conference for Scenario Planning, (November 24).

Coates, Joseph F. (1998). "Where Will Technology Take US?" *Physics World*, (October): 15–16.

Coates, Joseph F. (1998). "The Potential Benefits from Science and Engineering for the American Infrastructure, 1985–2015." *Physics World*, (October).

Coates, Joseph F. (1998). "Opportunities and Consequences in Science and Technology." *Research–Technology Management.*

Coates, Joseph F. (1998). "Readying Children for the Future." *Technological Forecasting and Social Change.*

Coates, Joseph F., John B. Mahaffie, and Andy Hines (1998). "The Promise of Genetics." *The Futurist*, World Future Society, (January–February).

Coates, Joseph F. (1997). "Long-Term Technological Trends and Their Implications for Management of New Technologies in Developing Countries." *International Journal of Technology Management, 14* (6/7/8).

Coates, Joseph F. (1997). "Engineering and the Future of Technology." *The Bridge*, (Fall).

Coates, Joseph F. (1997). "Historical Lessons from Technology Disruptions: Will the Storm Always Pass?" *Technological Forecasting and Social Change, 54*: pp. 111–117.

Coates, Joseph F. (1996). "An Overview of Futures Methods." *The Knowledge Base of Future Studies, Volume 2: Organizations, Practices, Products*. Hawthorne, Australia: DDM Media Group, Futures Study Centre, 57–75.

Coates, Joseph F. (1996). "Scientific Breakthroughs." *Encyclopedia for the Future.*

Coates, Joseph F. (1996). "What's Ahead for Families: Five Major Forces for Change." *The Futurist*, World Future Society (September–October).

Coates, Joseph F. (1995). "From My Perspective: A Thriving Future for Terrorism." *Technological Forecasting and Social Change, 51* (June 28): 295–299.

Coates, Joseph F., and Ashok Jain (1995). "Anticipating the Environmental Effects of Technology: A Primer and Workbook." *UNEP Industry and Environment*, (April–September).

Coates, Joseph F. (1995). "Looking Ahead: Scientists View the Future They Will Create." *Research–Technology Management*, (July–August).

Coates, Joseph F. (1995). "Brain Technology on the Way?" *Research–Technology Management*, (May–June).

Coates, Joseph F. (1995). "From My Perspective: A 50-Year Look Ahead." *Technological Forecasting and Social Change, 48*: 103–105.

Coates, Joseph F. (1994). "Robots Coming—Eventually." *Research–Technology Management*, (March–April).

Coates, Joseph F., and Jennifer Jarratt (1992). "Exploring the Future: A 200-Year Record of Expanding Competence." *AAPSS, 522* (July): 12–24.

Fowler, G. (in press). "Linking the Public Voice with the Genetic Policy Process: A Case Study." *Oregon's Future, III* (II) (Fall 2002): 28–33.

Fowler, G. (2002). "Linking Scientific Progress with Public Participation." *Proceedings of the Twelfth Annual Conference on Computers, Freedom, and Privacy*, (April 16–19).

Fowler, G., and B. Anderson (2000). "The Public Perceptions of the Rewards and Risks of Genetic Research: The Oregon story." *Professional Ethics Report*, American Association for the Advancement of Science, *XII* (4) (Fall).

Fowler, Gregory L. (2000). "Genetic Privacy Issues Call for Public Discussion." *The Oregonian*, (September 14).

Fowler, G. (1999). "The Human Genome Project—What's the Public Got to Do with It?" *Public Understanding of Science, 8*: 153–159.

Fowler, G., and M. Garland (1999). "Translating the Human Genome Project into Social Policy: A Model for Participatory Democracy." In Launis, Veikko, Pietarinen, Juhani, and Raikka (Eds.) *Genes and Morality: New Essays*. Amsterdam & Atlanta: Rodopi, 175–193.

Fowler, Gregory L. (1999). "Bioethics: On the Move in Oregon High Schools." *The Oregon Science Teacher*, *40* (5) (May/June).

Fowler, Gregory L. "Teaching the New Genetics." http://www.geneforum.org/organization/press.cfm.

Hughes, James J. (Under review). "Relinquishment or Regulation: Dealing with Apocalyptic Technological Threats." http://www.changesurfer.com/Acad/RelReg.pdf.

Hughes, James J. (Under review). "The Politics of Transhumanism." http://www.changesurfer.com/Acad/TranshumPolitics.htm.

Heckathorn, D. D., R. S. Broadhead, **J. J. Hughes**, and S. Semaan (2002). "Extensions of Respondent-Driven Sampling: A New Approach to the Study of Injection Drug Users Aged 18–25." *AIDS and Behavior* (forthcoming).

Hughes, James J. (2002). "The Battle for Human Dignity," *Transhumanity*, (October 2). [http://www.transhumanism.com].

Hughes, James J. (2002). "Democratic Transhumanism," *Transhumanity*. (April 28). [http://www.transhumanism.com].

Hughes, James J. (2001). "The Future of Death: Cryonics and the Telos of Liberal Individualism," *Journal of Evolution and Technology*, *6* (June). [http://transhumanist.com/index.html].

Hughes, James J. (1999). "Liberty, Equality and Solidarity in our Genetically Engineered Future." In Gregory Stock and John Campbell (Eds.) *Engineering the Human Germline*. Oxford University Press, 130–132.

Hughes, James J. (1999). "Buddhism and Abortion: A Western Approach." In Damien Keown (Ed.) *Buddhism and Abortion*. MacMillan.

Hughes, James J. (1999). "Paying Injection Drug Users to Educate and Recruit Their Peers: Why Participant-Driven Interventions Are an Ethical Public Health Model." *Quality Management in Health Care*, *7* (4) (Summer): 4–12.

Broadhead, R. S., D. D. Heckathorn, D. L. Weakliem, D. L. Anthony, H. Madray, R. J. Mills, and **J. J. Hughes** (1998). "Harnessing Peer Networks as an Instrument for AIDS Prevention: Results from a Peer-Driven Intervention." *Public Health Reports*, *113* (1) (June): 42–57.

Hughes, James J. (1997). "Brain Death and Technological Change: Personal Identity, Neural Prostheses and Uploading." Translated into German in *Telepolis*, (August). [http://www.heise.de/tp/deutsch/special/bio/2179/1.html].

Hughes, James J. (1997). "Utilitarianism and the Genetic Welfare of Future Generations: A Reply to Salvi." *Eubios Journal of Asian and International Bioethics*, *7* (March): 38–39.

Hughes, James J. (1997). "Duplicity about Duplication: Cloning as Lens for Millennial Angst." In English and in German in *Telepolis*, (March). [http://www.heise.de/tp/deutsch/special/bio/2179/1.html].

Hughes, James J. (1997). "Review of Armstrong and Armstrong's *Wasting Away: The Undermining of Canadian Health Care*." *American Journal of Sociology*, (May).

Carter, D., J. Lantos, and **J. Hughes** (1996). "Reassessing Medical Students' Willingness to Treat HIV-Infected Patients." *Academic Medicine*, *71*(11) (November): 1250–1252.

Hughes, James J. (1996). "Embracing Change with All Four Arms: A Defense of Human Genetic Engineering." In English and translated into German, *Telepolis* [http://www.heise.de/tp/]; *Eubios Journal of Asian and International Bioethics*, *6* (4): 94–101; In Thomas Easton (Ed.) *Taking Sides: Clashing Views on Controversial Issues in Science, Technology, and Society*. Dushkin Pub./McGraw-Hill, 311–322.

Hughes, James J. (1996). "Managed Care, University Hospitals and the Doctor-Nurse Division of Labor." *Research in the Sociology of Health Care, Volume 13A*. JAI Press, 63–92.

Hughes, James J. (1995). "Aliens, Technology and Freedom: SF Consumption and SocioEthical Attitudes." *Futures Research Quarterly*, *11* (4) (Winter): 39–58.

Hughes, James J. (1995). "Doctors Are Dinosaurs in a High-Tech World." *New York Newsday*, (July 1).

Hughes, James J., and Damien Keown (1995). "Buddhist Bioethics: A Bibliographic Essay." *Journal of Buddhist Ethics*, (June).

Hughes, James J. (1993). "Review of Zussman's *Intensive Care: Medical Ethics and the Medical Profession*." *American Journal of Sociology*, (June).

Hughes, James J. (1993). "Beginnings and Endings: The Buddhist Mythos of the Arising and Passing Away of the World." In Sulak Sivaraksa, et al (Eds.) *Buddhist Perceptions of Desirable Societies in the Future*. Bangkok: UN Univ./IRCD.

Stock, Gregory (In prep.). *In the Future … The Book of Questions*. New York: Workman Press.

Stock, Gregory (2002). *Redesigning Humans: Our Inevitable Genetic Future*. Houghton Mifflin (US), Profile (Britain), Japan, Korea. Paperback (Mariner, April 2003).

Stock, Gregory, and John Campbell (Eds.) (2000). *Engineering the Human Germline: An Exploration of the Science and Ethics of Altering the Genes We Pass to Our Children*. Oxford University Press.

Stock, Gregory (1993). *Metaman: The Merging of Humans and Machines into a Global Superorganism*. Simon & Schuster (NY), Doubleday (Toronto), Bantam (Britain), Mondadori (Italy), Kadakawa (Tokyo), Soho (China).

Stock, Gregory (1991). *Business, Politics, and Ethics: The Book of Questions*. New York: Workman.

Stock, Gregory (1987). *The Book of Questions*. New York: Workman. *Translations*: Spanish, French, Italian, Chinese, German, Swedish, Dutch, Danish, Norwegian, Finnish, Japanese, Portuguese, Icelandic, Hebrew, Hungarian, Slovakian, and Bulgarian.

Stock, G., and F. Fukuyama (2002). "Biotechnology: Our Slippery Slope?" (An exchange of letters). *Prospect*, *75* (June): 16–20.

Stock, G. (2002). "Choosing Our Children's Genes." *The Futurist*, (July/August).

de Grey, A., J. Baynes, D. Berd, C. Heward, G. Pawelec, and **G. Stock** (2002). "Is Human Aging Still Mysterious Enough to Be Left Only to Scientists?" *Bioessays*, (July).

Stock, G., and F. Fukuyama (2002). "Point–Counterpoint: Should We Allow Genetic Technologies with the Potential to Alter Human Biology?" *Reason*, (June).

Stock, G. (2002). "Do We Pull Back in Fear or Embrace the Future?" *London Times Higher Education Supplement*, (May 17).

Stock, G. (2002). "Homo ex Machina." In Gert Kaiser (Ed.) *Jahrbuch 2001/2002 des Wissenschaftszentrums Nordrhein-Westfalen.* Duesseldorf, Germany: Wissenschaftszentrum Nordrhein-Westfalen.

de Grey, A., B. Ames, J. Anderson, A. Bartke, J. Campesi, C. Heward, R. McCarter, and **G. Stock** (2002). "Time to Talk SENS: Critiquing the Immutability of Human Aging." In D. Harman (Ed.) *Increasing Healthy Life Span: Conventional Measures and Slowing the Innate Aging Process*. Proceedings of the 9th Congress of the International Association of Biomedical Gerontology. *Annals of the New York Academy of Sciences*, *959*:452–462. Full text: http://www.annalsnyas.org/cgi/content/full/959/1/452.

Stock, G., and J. Campbell (2002). "Public Policy Recommendations for Human Germline Engineering." In *Current Controversies: Genetic Engineering*. The Gale Group.

Stock, G. (2002). "The Future of Human Reproduction." BBC's *Science Now*, (January).

Stock, G. (2001). "Unvermeidbare Designer-Babys." Invited Guest Commentary, *Deutschland Financial Times*, (December 6): 30.

Stock, G. (2001). "Eggs for Sale—How Much Is Too Much?" *American Journal of Bioethics*, *1* (4) (Fall): 26–27.

Stock, G. (2001). "The Family Covenant: A Flawed Response to the Dilemmas of Genetic Testing." *American Journal of Bioethics*, *1*(3) (Summer): 17–18.

Stock, G. (2001). "The Genie Is Out of the Bottle," Opinion Piece, *Deutschland Magazine*, (April).

Stock, G. (2001). "Choice or Chance: Why Not Pick Our Children's Gender?" *American Journal of Bioethics*, *1*(1) (Winter): 36–37.

Stock, G. (2001). "The Coming Era of Human Biological Re-design." In George Enninga (Ed.) *The Future Is Ours—Evolution and Enlightenment*. London: Gordon and Breach Arts International; Amsterdam: OPA Publishing.

Stock, G. (2000). "Reflections on the Future of IVF and Germline Engineering." *ASRM News*, *34* (4) (Winter).

Stock, G. (2000) "Genetik: Die Vision vom Klon-Baby." Interview: "Visions of Clones" in "Was Ist Liebe?" *Focus Magazine*, *52* (December 22): 122–125, Germany. Online version: http://focus.de/F/2000/52/Technik/stock/stock.htm.

Stock, G. (2000). *L'égalité des chances pour tous.* Invited Commentary: "Remaking Our Bodies: What We Can Expect from Genetic Engineering." *Liberation*, (September 16), Paris. Also at http://www.liberation.com/chantiers/corps2.html.

Stock, G. (2000). "Genetic Profiling, Cloning, and Germline Enhancement: Challenges to Come." In C. Byrd, J. Hruschka, and J. Joerden (Eds.) *Jahrbuch für Recht und Ethik, Annual Review of Law and Ethics*, *Vol. 8*. Berlin: Duncker & Humblot.

Stock, G. (2000). "Playing God." *BMW Magazine*, (April).

Stock, G. (2000). "Patent Pending: The Debate about Gene Patents." *UCLA Magazine*, *12* (1) (Spring).

Stock, G. (2000). "End of the Beginning: The Genomics Revolution." *UCLA Today*, (August 29): 7.

Stock, G. (2000). "The Century Ahead." In *Visions of the Future from Leading Thinkers*, White House Publication; Invited Contribution, Internal Distribution.

Campbell, J., and **G. Stock** (1999). "A Vision for Practical Human Germline Engineering." Chapter 2 in **G. Stock** and J. Campbell (Eds.) *Engineering the Human Germline*. New York: Oxford University Press.

Stock, G., and J. Campbell. (1999). "Germline Intervention: An Evolutionary Perspective." Chapter 1 in **G. Stock** and J. Campbell (Eds.) *Engineering the Human Germline*. New York: Oxford University Press.

Stock, G. (1999). "Human Germline Engineering: Implications and Prospects." In C. Byrd, J. Hruschka, and J. Joerden (Eds.) *Jahrbuch für Recht und Ethik, Annual Review of Law and Ethics, Vol. 7*. Berlin: Duncker & Humblot.

Stock, G. (1998). "The Prospects for Human Germline Engineering." *Teleopolis*. Frankfurt, Germany.

Stock, G. (1998). "Human Germline Engineering: The Prospects for Commercial Development." Workshop on Genetic Manipulation in Animals. www.atp.nist.gov/atc/atc_hp. Advanced Technology Program, National Institute of Standards and Technology, Washington, DC.

Stock, G., and G. McGee (1997). "Should Human Cloning Be Banned?" Brain-Tennis Debate, http://www.hotwired.com/synapse/braintennis, HotWired, San Francisco.

Stock, G. (1996). "The Fourth Phase: Our Evolutionary Transition to a New Epoch in the History of Life." In E. Todd Ellison (Ed.) *Evoluting*. Los Angeles: Meridian Press.

Stock, Gregory (1999). *Human Germline Engineering: Implications for Science and Society*, a multimedia documentary funded by the Greenwall Foundation and developed through the UCLA School of Medicine: www.germline.ucla.edu.

Stock, Gregory (2001). *Questions and Answers,* a pilot site for a global discussion of issues of values, choices, and ethics. Based on *The Book of Questions* series. www.bookofquestions.com.

Postma, P. W., and **J. B. Stock** (1980). "Enzymes II of the Phosphotransferase System Do Not Catalyze Sugar Transport in the Absence of Phosphorylation." *J. Bacteriol. 141*: 476–484.

Koshland, D. E., Jr., A. Goldbeter, and **J. B. Stock** (1982). "Amplification and Adaptation in Regulatory and Sensory Systems." *Science, 217*: 220–225.

Stock, J. B. (1991). "Balancing Effector Outputs." *Current Biology, 1*: 154–156.

Lupas, A., M. V. Dyke, and **J. B. Stock** (1991). "Predicting Coiled-Coils from Protein Sequences." *Science, 252*: 1162–1164.

Philips, M. R., R. Staud, M. H. Pillinger, C. Volker, M. G. Rosenfields, G. Weissmann, and **J. B. Stock** (1993). "Carboxyl Methylation of Ras-Related Proteins during Signal Transduction in Neutrophils." *Science, 259*: 977–980.

Pillinger, M. H., C. Volker, **J. B. Stock**, G. Weissmann, and M. R. Philips (1994). "Characterization of a Plasma Membrane-Associated Prenylcysteine-Directed _-Carboxyl Methyltransferase in Human Neutrophils." *J. Biol. Chem., 269*: 1486–1492.

Stock, J., and M. Surette (1994). "The Motor Connection." *Curr. Biol., 4*: 143–144.

Philips, M. R., R. Staud, M. H. Pillinger, C. Volker, **J. B. Stock**, and G. Weissmann (1995). "Activation-Dependent Carboxyl Methylation of Neutrophil G-Protein _-Subunits." *Proc. Natl. Acad. Sci. U.S.A., 92*: 2283–2287.

Stock, J., and M. G. Surette (1996). "Chemotaxis." In J. L. Ingraham (Ed.) *Escherichia Coli and Salmonella Typhimurium: Cellular and Molecular Biology.* 2nd ed. Washington, DC: American Society of Microbiology, 1103–1129.

Hakenbeck, R., and **J. B. Stock** (1996). "Analysis of Two-Component Signal Transduction Systems Involved in Transcriptional Regulation." *Meth. Enzymol., 273*: 281–300.

Stock, J. (1996). "Receptor Signaling: Dimerization and Beyond." *Curr. Biol., 6*: 825–827.

Stock, J. B. (1996). "Signaling across Membranes." *Science, 274:* 370–371.

Liu, Y., M. Levit, R. Lurz, M. G. Surette, and **J. B. Stock** (1997). "Receptor-Mediated Protein Kinase Activation and the Mechanism of Transmembrane Signaling in Bacterial Chemotaxis." *EMBO J., 16:* 101–110.

Grebe, T., and **J. B. Stock** (1998). "Bacterial Chemotaxis: The Five Sensors of a Bacterium." *Current Biology, 8*: R154–R157.

Levit, M., Y. Liu, and **J. B. Stock** (1998). "Stimulus Response Coupling in Bacterial Chemotaxis: Receptor Dimers in Signaling Arrays." *Mol. Micro., 29*: 459–466.

Stock, J. B. (1999). "Sensitivity, Cooperativity and Gain in Chemotaxis Signal Transduction." *Trends in Microbiol., 7*, 1–4.

Elowitz, M. B., M. G. Surette, P.-E. Wolf, **J. B. Stock**, and S. Leibler (1999). "Protein Mobility in the Cytoplasm of Escherichia Coli." *J. Bacteriol., 181*: 197–203.

Stock, J. B. (1999). "Signal Transduction: Gyrating Protein Kinases." *Current Biology, 9*: R364–R367.

Djordjevic, S., A. M. Stock, Y. Chen, and **J. B. Stock** (1999). "Protein Methyltransferases Involved in Signal Transduction." In X. Cheng and R. M. Blumenthal (Eds.) *S-Adenosylmethionine-Dependent Methyltransferases: Structures and Functions.* Singapore: World Scientific Publishing Co., 149–184.

Da Re, S. S., D. Deville-Bonne, T. Tolstykh, M. Vèron, and **J. B. Stock** (1999). "Kinetics of CheY Phosphorylation by Small Molecule Phosphodonors." *FEBS Lett., 457*: 323–326.

Hakenbeck, R., T. Grebe, D. Zähner, and **J. B. Stock** (1999). "β-Lactam Resistance in Streptococcus Pneumoniae: Penicillin-Binding Proteins and Non-Penicillin-Binding Proteins." *Mol. Microbiol., 33*: 673–678.

Grebe, T., and **J. B. Stock** (1999). "The Histidine Kinase Superfamily." *Adv. Microbial Phys., 41*: 139–227.

Stock, J. B., and S. Da Re (1999). "A Receptor Scaffold Mediates Stimulus-Response Coupling in Bacterial Chemotaxis."*Cell Calcium, 26*: 157–164.

Thomason, P. A., D. Traynor, **J. B. Stock**, and R. R. Kay (1999). "The RdeA-RegA System: A Eukaryotic Phospho-Relay Controlling cAMP Breakdown." *J. Biol. Chem., 274*: 27379–27384.

Stock, J. B., and M. Levit (2000). "Signal Transduction: Hair Brains in Bacterial Chemotaxis." *Current Biology, 10*: R11–R14.

Stock, J. B., and S. Da Re (2000). "Signal Transduction: Response Regulators On and Off." *Current Biology, 10*: R420–R424.

Stock, J. B., and S. Da Re (2000). "Chemotaxis." In J. Lederberg (Ed.) *Encyclopedia of Microbiology*. 1st and 2nd ed. San Diego, CA: Academic Press, 772–780.

Tolstykh, T., J. Lee, S. Vafai, and **J. B. Stock** (2000). "Carboxyl Methylation Regulates Phosphoprotein Phosphatase 2A by Controlling the Association of Regulatory B Subunits." *EMBO J., 19*: 5682–5691.

Wu, J., T. Tolstykh, J. Lee, K. Boyd, **J. Stock**, and J. R. Broach (2000). "Carboxyl Methylation of the Phosphoprotein Phosphatase 2A Catalytic Subunit Promotes Its Functional Association with Regulatory Subunits in Vivo." *EMBO J., 19*: 5672–5681.

Mourey, L., S. Da Re, J. D. Pedelacq, T. Tolstykh, C. Faurie, V. Guillet, **J. B. Stock**, and J. P. Samama (2001). "Crystal Structure of the CheA Histidine Phosphotransfer Domain that Mediates Response Regulator Phosphorylation in Bacterial Chemotaxis." *J. Biol. Chem., 276*: 31074–31082.

Levit, M., B. Abramczyk, **J. B. Stock**, and E. Postel (2002). "Interactions between E. Coli Nucleoside Diphosphate Kinase and DNA." *J. Biol. Chem., 277*: 5163–5167.

Vafai, S., and **J. B. Stock** (2002). "Protein Phosphatase 2A Methylation: A Link between Elevated Plasma Homocysteine and Alzheimer's Disease." *FEBS Lett., 518*: 1–4.

Stock, J. B., M. Levit, and P. M. Wolanin (2002). "Information Processing in Bacterial Chemotaxis." *Science's STKE, 132*: PE25.

Thomason, P. A., P. M. Wolanin, and **J. B. Stock** (2002). "Signal Transduction: Receptor Clusters as Information Processing Arrays." *Current Biology, 12*: R399–R401.

Wolanin, P. M., P. A. Thomason, and **J. B. Stock** (2002). "Histidine Protein Kinases: Key Signal Transducers Outside the Animal Kingdom." *Genome Biology, 3*: 3013.1–3013.8.

Wolanin, P. M., and **J. B. Stock** (2002). "Transmembrane Signaling and the Regulation of Histidine Kinase Activity." In M. Inouye and R. Dutta (Eds.) *Hisidine Kinases in Signal Transduction.* New York: Academic Press.

Levit, M., and **J. B. Stock** (2002). "Receptor Methylation Controls the Magnitude of Stimulus-Response Coupling in Bacterial Chemotaxis." *J. Biol. Chem.*

Levit, M., T. Grebe, and **J. B. Stock** (2002). "Organization of the Receptor-Kinase Signaling Array that Regulates E. Coli Chemotaxis." *J. Biol. Chem.*

Francis, N. R., M. Levit, T. R. Shaikh, L. A. Melanson, **J. B. Stock**, and D. J. DeRosier (2002). "Subunit Organization in a Soluble Complex of Tar, CheW, and CheA by an Electron Microscopy." *J. Biol. Chem.*

Da Re, S., T. Tolstykh, P. M. Wolanin, and **J. B. Stock** (2002). "Genetic Analysis of Response Regulator Activation in Bacterial Chemotaxis Suggests an Intermolecular Mechanism." *Protein Science.*

Zimmerman, Burke K. (1984). *Biofuture: Confronting the Genetic Era*. Perseus Publishing.

Zilinskas, Raymond A., and **Burke K. Zimmerman** (Eds.) (1986). *Gene Splicing Wars: Reflections on the Recombinant DNA Controversy*. The Free Press.

Zimmerman, Burke K. (1999). "The Use of Genetic Information and Public Accountability." *Public Understanding of Science, 8*: 223–240.

Appendix VI

Selected Articles

As background reading for "The Future Human" Workshop, the Foundation gathered a number of related articles by workshop participants, as listed below. These articles are available on the Foundation website, www.futurefoundation.org:

Anderson, W. French (1989). "Human Gene Therapy: Why Draw a Line?" *The Journal of Medicine and Philosophy, 14*: 681–693.

Anderson, W. French (2000). "A Cure That May Cost Us Ourselves." *Newsweek* (January 1): 75–76.

Andreadis, Athena. "Earth Brains, Star Minds." http://www.toseekoutnewlife.com/TPS.html.

Andreadis, Athena (2000). "Making Aliens: The Repercussions of Planetary Settlement." Speech presented at the Apollo 2000 Rendezvous of the Ohio Valley Astronomical Society (June 10).

Campbell, John H. (1995). "The Moral Imperative of Our Future Evolution." In R. Wesson and P. Williams (Eds.) *Evolutionary Journeys*. Amsterdam: Rodopi Press, 79–114.

Coates, Joseph, F. (1999). "Thinking About Humanity in the Year 3000." *Futures Research Quarterly* (Winter).

Coates, Joseph F., John B. Mahaffie, and Andy Hines (1998). "The Promise of Genetics." *The Futurist*, World Future Society, (January-February).

Fowler, G. Linking the Public Voice with the Genetic Policy Process: A Case Study." *Oregon's Future, III* (II) (Fall 2002): 28–33.

Fowler, G., and M. Garland (1999). "Translating the Human Genome Project into Social Policy: A Model for Participatory Democracy." In Launis, Veikko, Pietarinen, Juhani, and Raikka (Eds.) *Genes and Morality: New Essays*. Amsterdam & Atlanta: Rodopi, 175–193.

Hughes, James J. (2001). "The Future of Death: Cryonics and the Telos of Liberal Individualism." *Journal of Evolution and Technology*, *6* (June). [http://transhumanist.com/index.html]

Hughes, James J. (2002). "The Battle for Human Dignity," *Transhumanity*, (October 2). [http://www.transhumanism.com].

Stock, Gregory (2002). "The Last Human." Excerpt from *Redesigning Humans*. New York: Houghton Mifflin.

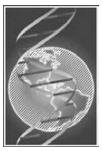
Stock, Gregory (1993). "A Fusion of Technology and Biology: The Nonhuman Constituents of Metaman." Excerpt from *Metaman*. New York: Simon & Schuster.

Wolanin, Peter M., Peter A. Thomason, and **Jeffry B. Stock** (2002). "Histidine Protein Kinases: Key Signal Transducers Outside the Animal Kingdom." *Genome Biology, 3*: 3013.1–3013.8.

Stock, J. B. (1999). "Sensitivity, Cooperativity and Gain in Chemotaxis Signal Transduction." *Trends in Microbiol., 7*: 1–4.

Zimmerman, Burke K.(1999). "The Use of Genetic Information and Public Accountability." *Public Understanding of Science, 8*: 223–240.

Zimmerman, Burke K. (1984). Excerpt from *Biofuture: Confronting the Genetic Era*. New York: Plenum Press.



Foundation For the Future
123 105th Avenue SE
Bellevue, WA USA 98004-6265

Tel: (425) 451-1333
Email: info@futurefoundation.org
Website: www.futurefoundation.org