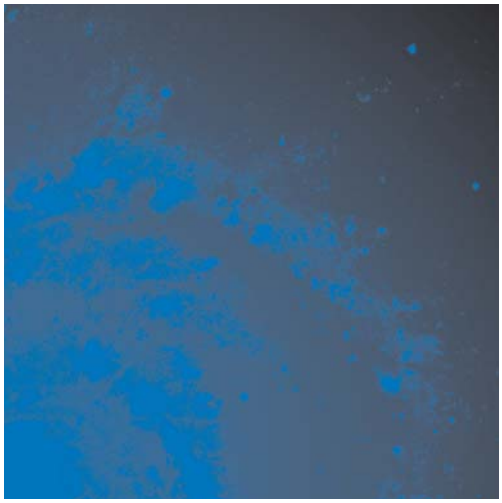
A CHRONICLE

Prof. John D. Barrow
2006 Templeton Prize Laureate



TEMPLETON PRIZE

For Progress Toward Research or Discoveries About Spiritual Realities

including research in love, creativity, purpose, infinity, intelligence, thanksgiving and prayer.

Templeton Prize Press Conference | New York City | March 15, 2006
Templeton Prize Luncheon Media Briefing | London | May 3, 2006
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STATEMENT BY

John M. Templeton, Jr., M.D.

AT THE TEMPLETON PRIZE PRESS CONFERENCE, NEW YORK CITY, MARCH 15, 2006

Good morning. As President of the John Templeton Foundation, it is my privilege and pleasure to welcome all of you to the annual news conference for the announcement of the 2006 Templeton Prize.

I'd like to take the opportunity to thank each and every one of you for attending this morning. I would also like to express a very special welcome to the 2006 Templeton Prize Laureate, Professor John D. Barrow of the University of Cambridge. It is a great honor for us to have Dr. Barrow with us this morning to share some comments and later to answer your questions. Our format this morning is as follows. First, I shall share with you some of the perspectives of my Father, Sir John Templeton, when he established the Templeton Prize program some 35 years ago, and when he spoke with us here three years ago. Because my Father is now 93 years of age, he finds that the rigors of international travel, with the long waiting lines to get through security, are overly arduous. He sends his sincerest apologies, therefore, for his not being able to be with us this year, but he also wants to express his joy in the wisdom of the judges in recognizing the remarkable accomplishments of John Barrow as the 2006 Templeton Prize Laureate.

After a few comments about the vision of the Prize program, I shall present some of the accomplishments of Dr. Barrow, which clearly guided the judges in their selection. After this introduction, Dr. Barrow will share with us some of the perspectives of his work in physics and mathematics and cosmology and also in the growing field of Science and Religion, which has had extraordinary growth just in the last 15 years. Then, after his remarks, we will open the floor to your questions.

The Templeton Prize continues to be the world's largest annual prize given to an individual for individual accomplishment. This year's award is in the amount of £795,000 Sterling, which as of the close of the market yesterday was about $1.4 million.

You may recall that four years ago the name of the Prize, which is now in its thirty-fourth year, was changed to: The Templeton Prize for Progress Toward Research or Discoveries About Spiritual Realities. In fact, for many years we have been looking for ways to draw greater attention to the idea that progress in spiritual information and spiritual discoveries is just as feasible as it is in well-established sciences such as physics, medicine, chemistry, and so on. In fact, spiritual progress may be more important than all of these other areas. Therefore, the name of the Prize was changed to inspire greater attention to research or discoveries of a spiritual nature. Spiritual realities refer to matters of the soul that are universal and apply to all cultures and all peoples. Examples would include subjects like love, purpose, infinity, prayer, and thanksgiving. These realities are non-material, transcendent or metaphysical areas about which many people have intuitive perceptions.

The Prize is given each year in honor of a living person who represents through his or her work a remarkable spirit of inquiry to understand not only the nature of these realities, but also the nature of the divinity which gives life to these spiritual realities. The inquiry can come in many forms, including scientific research or other methods of discovery by which knowledge might compliment ancient scriptures and traditions in opening our eyes more fully to our growing understanding of God's nature and purpose. This spirit of inquiry may involve a scholarly commitment to the growing field of Science and Religion as

demonstrated by the extraordinary career and productive work of Dr. Barrow.

Three years ago, my Father shared with us some of his perspectives that crystallize the meaning of this Prize program. He said, "Let me go back to some examples. Until three centuries ago, spiritual information and scientific information were regarded as one unit. But then a divergence took place. Science began to advance strongly into experimental science research, and as a result, we have witnessed the most glorious race ahead.

"Let's take medicine: We know at least a hundred times as much about your body as we knew just one century ago. Unfortunately, this has not happened in regard to spiritual information or discoveries about spiritual realities.

"Or take any one of the other sciences: There is no major science that has not just raced ahead. So we live in the most glorious, rapidly improving time in all of the world's history – except in our knowledge of divinity.

"Why is such a vision of progress not true in spiritual matters? It's because of an unintentional attitude. Nobody planned it; nobody even realizes that perhaps that attitude is there. But it is the idea that, when you are trying to do research of a spiritual nature, you must look back hundreds if not thousands of years, and not into current discoveries. So why can we not get all of the world's people to be enthusiastic rather than resistant to new concepts in the field of spiritual information and discoveries about spiritual realities?"

In his comments here three years ago, my Father went on to say: "I think I can convince almost anybody that there has never been a human being who knew even one percent of what might be known about God. Almost everybody in the Western world believes there is a God but the amount of high quality scientific research done on the aspects of divinity is tiny."

Therefore, what we are trying to do through this Prize program and many of our other programs for the John Templeton Foundation, is to change that attitude so that everyone, including theologians, becomes as enthusiastic for new discoveries just as people are in chemistry or medicine or physics or anything else.

If we can do that, the benefits are likely to be even greater. If we can get the world to spend even ten percent as much on spiritual research as the world does in scientific research, more will be discovered. With such an investment, it is possible that by the end of this century, humans will know perhaps one hundredfold more about the nature of divinity, and the nature of creativity, than anybody ever knew before.

John M. Templeton, Jr. at the Templeton Prize Press Conference.

The benefits, therefore, are likely to be even greater than the benefits that have come from medicine or chemistry or physics.

Cosmology, for example, is a field that holds great promise in regard to this vision of discovery. It is useful to reflect on the fact that discoveries in all of the sciences, including cosmology, have contributed to our understanding of how large is God, thereby suggesting what we can learn about God. As noted, some fields like cosmology can especially contribute to helping humanity understand aspects of divinity. In highlighting this vision, my Father said: "All of this points toward tremendous blessings for humanity and that is what I am devoting my life to. My challenge to you is that if you want to be happy, if you want to be of benefit to humanity, you will not come up with anything more beneficial than new discoveries about spiritual realities including the nature of God and his purposes for us."

"My challenge to you is that if you want to be happy, if you want to be of benefit to humanity, you will not come up with anything more beneficial than new discoveries about spiritual realities including the nature of God and his purposes for us."

That line of thinking explains why we are here today. Years ago my Father looked at the work of Alfred Nobel and discovered that by giving five Prizes in Chemistry, Physics, Medicine and so forth, he had persuaded the most brilliant people on earth to devote a huge amount of attention to discovery – discoveries in Physics, Medicine and so forth. Brilliant people who might not otherwise have made these discoveries were inspired by the fact that other people had discovered something important and were recognized by winning one of his distinguished Prizes.

Nevertheless, my Father, Sir John, felt that Alfred Nobel had a blind spot when it came to spiritual discovery. He said: "I, therefore, established this Prize program to encourage an attitude of progress in the domain of religion and also a spirit, even an enthusiasm, for a quest for discovery regarding spiritual realities. I feel that this quest will have the most powerful and beneficial impact in the whole realm of research and discoveries – an impact that will advance the well being of each individual and the world as a whole."

Again, my Father regrets very much that he is not able to be with us today to share in our recognition of this year's winner, Professor John D. Barrow of the University of Cambridge. In my Father's absence, I would like to briefly share with you some of the extraordinary background and lifetime work of Dr. Barrow. His is a career of remarkable accomplishments, which clearly guided the judges in their selection of him as this year's winner.

Many of the details of his accomplishments are highlighted in the press package which you have received. But let me take a few moments to highlight some of his remarkable life's work.

First, speaking on behalf of my Father and the Templeton Prize program, we are very grateful that Professor Thomas Torrance – who himself was a winner of the Templeton Prize in 1978 – put in so much time and care in the nomination of Professor John Barrow for evaluation by the judges of the

Templeton Prize program. Unfortunately, Professor Torrance is not able to be with us, but he sends his warmest congratulations and best wishes.

In his nomination, Professor Torrance noted the extraordinary career of Professor Barrow in the field of mathematics, astrophysics, and astronomy. Professor Barrow's distinguished career and his numerous accomplishments in mathematics and science, contributed to his election as a Fellow of the Royal Society of London in 2003. At the same time, for the past two decades Professor Barrow has also written and spoken extensively on the need to bridge the two major domains of knowing – namely Science and Religion. He has done this through dialogue, research, and communications of a worldwide nature.

After only nine years following his receipt of a Bachelor of Science with first class honors in mathematics at Durham University, Professor Barrow published his first book on cosmology entitled, *The Left Hand of Creation: The Origin and Evolution of the Expanding Universe.*

Only three years later, Professor Barrow co-authored a book entitled *The Anthropic Cosmological Principle.* This book has been enormously influential in discussions between religious and scientific perspectives on the universe. It has been cited very heavily across the spectrum of scholarly study from studies of natural theology, philosophy, physics, mathematics, and astronomy. Of particular interest to the theology-science interface is the detailed history of design arguments and natural theology, to which Dr. Barrow contributed with the modern cosmological forms of the Anthropic Principle.

Professor Barrow has continued to make extraordinary contributions in his main fields of mathematics, astrophysics, and astronomy with many fellowships and appointments as lecturer at the University of California, Oxford University, and the University of Sussex, and his appointment in 1999 as Professor of Mathematical Sciences at Cambridge University. Nevertheless, in his quest to understand more of the critical issues in cosmology and Science and Religion he has written 17 books and approximately 400 articles – often dealing with the important distinction between the laws of Nature and the outcomes of these laws. The growing respect that his work attracted can be seen in the fact that in 1989, Professor Barrow was selected to deliver the Gifford Lectures at Glasgow University. This was an especially auspicious selection in that Professor Barrow was the youngest Gifford Lecturer ever and he gave his address in the centennial year of the Gifford Lectures program. These lectures attracted capacity audiences throughout their course.

The Gifford Lectures gave rise to another of Professor Barrow's important books entitled, *Theories of Everything.* It was the first book to lay out the meaning of a Theory of Everything in the parlance of particle physics for a broader educated audience. This book carefully showed why such theories were necessary but never sufficient for understanding the world around us. Instead, Professor Barrow identified other ingredients necessary for a full understanding of the physical world.

This seminal work showed the limitations of the meaning of the word "everything" for particle physics. Its subject matter is at the heart of debates over reductionism and emergence and it shows clearly what the efforts of a search for a theory of everything would leave unexplained.

Then in his 1998 book, *Impossibility: The Limits of Science and the Science of Limits,* published by Oxford University Press, Professor Barrow gave a wide-ranging discussion of the limits of human knowledge. He showed how a precise understanding of what we cannot know and cannot do about the universe turns out to be a profound ingredient in our understanding of it. We learn from his book that there are deep limits to human understanding of the universe, no matter how perfect our intellectual or experimental capabilities are.

In addition to these prolific and penetrating contributions, Professor Barrow has continued to make critical contributions in conjunction with his appointment in 1999, as Director of the Millennium Mathematics Project – an initiative to improve the understanding and appreciation of mathematics and its application among young people and the public as a whole. More recently, Professor Barrow wrote two complimentary books, *The Book of Nothing* and *The Infinite Book,* which provide the widest discussion of all aspects of nothingness, zero, and the timeless, boundless, and endless qualities of the infinite.

"The hallmark of Barrow's work is a deep engagement with those aspects of the structure of the universe and its laws that make life possible and which shape the views that we take of that universe when we examine it."

The subjects of these two books are ones that have been proven to be pivotal in the history of ideas. While there have been many new developments in the scientific approach to infinity in recent years, his book, *The Infinite Book,* was the first to divulge all these ideas to a wider audience of thinkers interested in the overlap between science and religion.

In his nomination, Professor Torrance summarized the extraordinary productivity and uniqueness of Professor Barrow's many contributions – contributions that the judges clearly felt warranted the selection of Professor Barrow for the 2006 Templeton Prize. Quoting Professor Torrance:

"The hallmark of Barrow's work is a deep engagement with those aspects of the structure of the universe and its laws that make life possible and which shape the views that we take of that universe when we examine it. The vast elaboration of that simple idea has lead to a huge expansion of the breadth and depth of the dialogue between science and religion."

In summary, Professor Barrow's contributions have drawn in expert physicists, mathematicians, cosmologists, and philosophers to re-engage in a discussion with theologians and religious thinkers that might have faded away. Furthermore, his contributions have opened the door to new dimensions of understanding purpose – both in the domain of mankind and the domain of divinity.

It is from this framework of Professor Barrow's lifelong commitment to a quest for truth in the intersecting of both science and religion that I would like now to ask John Barrow, the 2006 Templeton Prize Laureate, to come forward and share some comments with us.

STATEMENT BY

Prof. John D. Barrow

AT THE TEMPLETON PRIZE PRESS CONFERENCE, NEW YORK CITY, MARCH 15, 2006

I feel very humble at being thought to have contributed to such critically important fields as spirituality and the purpose of life. I am enormously honored by this award, and deeply thank the John Templeton Foundation.

A little over a year ago I was in a great church – the Basilica of St. Mark in Venice. Its predecessor was raised in the year 832 to house the mortal remains of St. Mark the Evangelist which had supposedly been brought to Venice from Alexandria four years earlier by two Venetian merchants. They are alleged to have hidden the remains of the martyred Saint under layers of pork so as to avoid the attentions of Muslim customs officials.

The present Byzantine style Basilica with its distinctive cluster of low domes was begun in 1063 and consecrated in 1089. Today, it sits next to the Doge's Palace on the edge of St. Mark's Square, attracting tourists and pigeons rather than pilgrims with a façade to launch a thousand postcards.

I arrived at the church in the early evening with a small group of other scientists for a guided tour after it had closed to visitors for the day. When we entered it was almost in total darkness. There are few windows and those are small and far from transparent. We were asked to sit in the centre, allowing just a few faint floor lights and an occasional electric candle to guide us to our seats. Above us there was only darkness.

Then, very slowly, the light levels slowly rose, above us and around us, and the interior began to be illuminated by a discreet system of hidden sodium lights. The darkness around us gave way to a spectacular golden light. The arching ceilings above us were covered in a spectacular gleaming mosaic of glass and gold. Between the 11th and the 15th centuries nearly 11,000 square feet of gold mosaic was made, square by square, mixing gold with glass by a delicate process that it still not fully understood, to produce this sparkling golden sanctuary. Appearances can be deceptive.

But, on reflection, what was more striking to me was the realisation that the hundreds of master craftsmen who had worked for centuries to create this fabulous sight had never seen it in its full glory. They worked in the gloomy interior aided by candlelight and smoky oil lamps to illuminate the small area on which they worked but not one of them had ever seen the full glory of the golden ceiling. For them, like us, 500 years afterwards, appearances were deceptive.

John Barrow at the Templeton Prize Press Conference.

Our Universe is a bit like that too. The ancient writers who celebrated the heavens' declaration of the glory of the Lord saw only through a glass darkly. Unbeknown to them and countless others who followed them, the Universe has revealed itself by the instruments that modern science has made possible to be far bigger, more spectacular, and more humbling than we ever imagined it to be.

The Universe appears big and old, dark and cold, hostile to life as we know it, dangerous, and costly to explore. Many a philosopher of the past concluded that the Universe was meaningless and antithetical to life: a bleak and black realm in which our little planet is a temporary outcome of the blind forces of Nature. Yet, appearances may again be deceptive.

Over the past 75 years, astronomers have illuminated the vault of the heavens in a completely unexpected way. The Universe is not only big but it is getting bigger. It is expanding. Great clusters of galaxies are moving away from each other at increasing speeds. This means that the size of the Universe we can see is inextricably bound up with its age. It is big because it is old.

These huge periods of time are important for our own existence. We are made of complicated atoms of carbon, nitrogen and oxygen, along with many others; maybe one day other forms of terrestrial intelligence will be made of silicon atoms. The nuclei of all these atoms do not come ready-made with the Universe. They are put together by a long slow-burning sequence of nuclear reactions in the stars. It takes almost 10 billion years for this stellar alchemy to burn hydrogen to helium, and on to beryllium, and carbon and oxygen and beyond, before the dying stars explode in supernovae and spread their life-giving debris around the Universe where it finds its way into grains of dust, planets, and ultimately into people. The nucleus of every carbon atom in our bodies has been through a star. We are closer to the stars than we could ever have imagined.

So you begin to understand why it is no surprise that the Universe seems so big and so old. It takes nearly ten billion years to make the building blocks of living complexity in the stars and because the Universe is expanding it must be at least ten billion light years in size. We could not exist in a Universe that was significantly smaller.

The vastness of the Universe is often cited as evidence for the extreme likelihood of life elsewhere. While there may be life – even conscious life – elsewhere, sheer size is not compelling: we see that the Universe needs to be billions of light years in size just to support one lonely outpost of life. An economy-sized Universe, just the size of our Milky Way Galaxy, with its 100 billion stars and possible planetary systems, seems room enough for all we hold dear. But it would be little more than a month old. Barely enough time to pay off your credit card bill, let alone evolve complexity and life from sub-atomic simplicity.

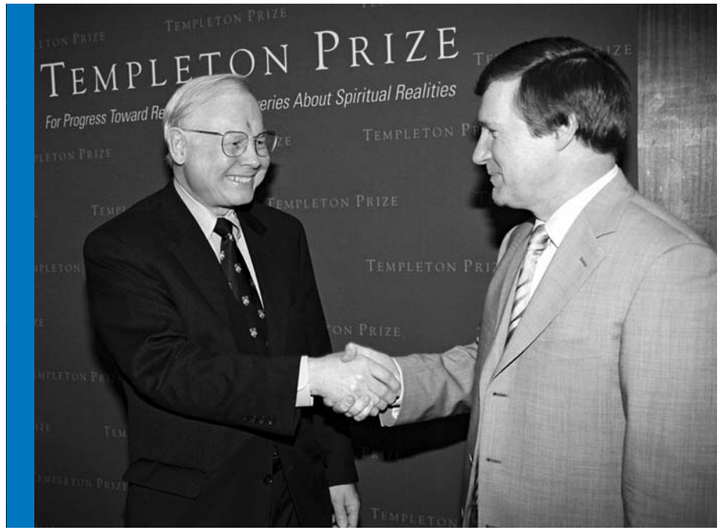
Any Universe that is a home for life must be big and old. But this means that it must also be dark and cold. As time passes, the expanding Universe gets cooler and cooler, and energies fall as space is stretched. The inferno of the past "big bang" must, after billions of years, be replaced by the dark night sky we see around us containing just a faint glimmer of microwaves, echoing its hot beginnings, just three degrees above absolute zero of cold, but still detectable in the snow of white noise on an untuned TV screen in our living rooms. The dark night sky that provoked so many human responses to our place in the Universe is a necessary part of a life-supporting Universe.

Life can only arise and persist in a Universe that is big and old, dark and cold, with its planets and stars and

galaxies separated by vast distances. These are necessary features of a life-supporting Universe. Astronomy has transformed the simple-minded, life-averse, meaningless Universe of the sceptical philosophers. It breathes new life into so many religious questions of ultimate concern and never-ending fascination. Many of the deepest and most engaging questions that we grapple with still about the nature of the Universe have their origins in our purely religious quest for meaning. The concept of a lawful Universe with order that can be understood and relied upon emerged largely out of religious beliefs about the nature of God. The atomistic picture of matter arose long before there could have been any experimental evidence for or against it. Out of these beliefs came confidence that there was an unchanging order behind the appearances that was worth studying. Great questions about the origin and end of the Universe, possibly the sources of all observed complexity, and the potential infinity of space grew out of our religious focus on the great questions of existence and the nature of God. And, like all great questions, they can turn out to have answers that take us down unexpected paths, further and further away from the familiar and the everyday: multiverses, extra dimensions, the bending of time and of space – all may reveal a Universe than contains more than is needed for life, more even than is needed for speculation. We see now how it is possible for a Universe that displays unending complexity and exquisite structure to be governed by a few simple laws – perhaps just one law – that are symmetrical and intelligible, laws which govern the most remarkable things in our Universe – populations of elementary "particles" that are everywhere perfectly identical.

It is to this simple and beautiful world behind the appearances, where the lawfulness of Nature is most elegantly and completely revealed, that physicists look to find the hallmark of the Universe. Everyone else looks at the outcomes of these laws. The outcomes are often complicated, hard to understand, and of great significance – they even include ourselves – but the true simplicity and symmetry of the Universe is to be found in the things that are not seen. Most remarkable of all, we find that there are mathematical equations, little squiggles on pieces of paper, that tell us how whole Universes behave. For there is a logic larger than Universes that is the more surprising because we can understand a meaningful part of it and thereby share in its appreciation.

Many of the deepest and most engaging questions that we grapple with still about the nature of the Universe have their origins in our purely religious quest for meaning.



John M. Templeton, Jr. congratulates John Barrow at the Templeton Prize Press Conference.

Once we thought everything in the Universe was made of the things material that we find on Earth. We have now discovered that this too was only a first guess. More than 70 percent of the Universe is composed of a form of dark energy whose precise identity is unknown. It reveals its presence by its dramatic effect upon the expansion of the Universe. Unlike all other known forms of matter, which exert gravitational attractive forces on other forms of matter and amongst themselves, this dark form of energy responds repulsively to gravity, causing all material to accelerate away from it, creating an acceleration in the expansion of the Universe that began to occur when it had reached about 75 percent of its present extent. This discovery about our Universe was a surprise – like discovering something totally unexpected about an old friend. Again, appearances were deceptive.

So, with the Universe, as it was that evening in St. Mark's, things are not always as they seem when we look upwards. The whole is so much more than the sum of its parts. The architects of our religious and scientific pictures of the Universe, and the many commentators on their meanings that followed them, could see only a small part of what there is, and knew only a small part of what it has to teach us about our place in the Universe. We begin to see afresh the extraordinary nature of our local environment and the link that attaches life to the vastness of space and time. Appearances can indeed be deceptive.

There are some who say that just because we use our minds to appreciate the order and complexity of the Universe around us that there is nothing more to that order than what is imposed by the human mind. That is a serious misjudgement. Were it true then we would expect to find our greatest and most reliable understanding of the world in the everyday events for which millions of years of natural selection have sharpened our wits and prepared our senses. And when we look towards the outer space of galaxies and black holes, or into the inner space of quarks and electrons, we should expect to find few resonances between our minds and the ways of these worlds. Natural selection requires no understanding of quarks and black holes for our survival and multiplication. And yet, we find these expectations turned upon their heads. The most precise and reliable knowledge we have about anything in the Universe is of events in a binary star system more than 3000 light years from our planet and in the sub-atomic world of electrons and light rays, where it is accurate to better than nine decimal places. And curiously, our greatest uncertainties all relate to the local problems of understanding ourselves – human societies, human behaviour, and human minds – all the things that really mattered for human survival. But that is because they need to be complex – were our minds simple enough to be understood they would be too simple to understand.

In all the science we pursue we are used to seeing progress. Our first attempts to grasp the laws of Nature are often incomplete. They capture just a part of the truth or they see it through a glass only darkly. Some think that our progress is like a never-ending sequence of revolutions which overthrow the old order, condemned never to converge upon anything more definitive than a more useful style of thinking. But scientific progress doesn't look like that from the inside. Our new theories extend and subsume old ones. The former theories are recovered in some limited situations – slow motions, weak gravitational fields, large sizes, or low energies – from the new. Newton's 300-year-old theory of mechanics and gravity has been superseded by Einstein's which will be succeeded by M theory or its unknown successor in the future. But in a thousand years time schoolchildren will still study Newton's theories, and engineers will still rely upon them, just as they do today. They will be the simple limiting form for slow

motions and weak gravity of the ultimate theory, whatever it turns out to be. So, in our religious conceptions of the Universe, we also use approximations and analogies to have some grasp of ultimate things. They are not the whole truth but this does not stop them from being a part of the truth: a shadow that is cast in a limiting situation of some simplicity. Our scientific picture of the Universe has revealed time and again how blinkered and conservative our outlook has often been, how self-serving our interim picture of the Universe, how mundane our expectations, and how parochial our attempts to find or deny the links between scientific and religious approaches to the nature of the Universe.

Sir John Templeton has sought to encourage this impartial dialogue in the firm belief that religion and science can supply mutual illumination and appreciation of the wonders of our Universe and inspire us to seek out and comprehend the truth in new ways – a truth that is unfailingly unexpected and so often not at all like it first appears.

CLOSING STATEMENT BY

John M. Templeton, Jr., M.D.

AT THE TEMPLETON PRIZE PRESS CONFERENCE, NEW YORK CITY, MARCH 15, 2006

Again, I would like to warmly thank each and every one of you for attending this news conference this morning and for sharing your thoughts and questions.

I would also like to close with a special request from my Father. Specifically, he would, first, like to suggest that anyone here, or anyone who learns about the Prize and this year's winner, Professor Barrow, to please contact us with any ideas or suggestions you might have for improving the Prize program and, in particular, its outreach and impact.

Secondly, my Father would like to urge you or anyone you know to submit new nominations of individuals who have made singular accomplishments in the broad area of research and discoveries about spiritual realities. You can learn more about the Templeton Prize program and the criteria for applications by going to our Website, www.templetonprize.org.

On that note, please join me in giving one more round of applause and our expression of gratitude to the 2006 Templeton Prize Laureate, Professor John D. Barrow.

PRESENTATION OF THE

2006 Templeton Prize

AT BUCKINGHAM PALACE, LONDON, MAY 3, 2006

The Duke of Edinburgh with John Barrow and his family and friends at the Buckingham Palace ceremony.

John Barrow, John M. Templeton, Jr. and The Duke of Edinburgh at Buckingham Palace.

SELECTED REMARKS BY

Prof. John D. Barrow

AT THE TEMPLETON PRIZE LUNCHEON MEDIA BRIEFING, LONDON, MAY 3, 2006

A common factor that links the different activities and the interests I have is, simply, cosmology. But I'm interested in all aspects of cosmology, from astronomical and mathematical activities at the research level, to all the wider implications of our thinking about the universe – in philosophy, theology, and also its popularization, which helps the public to understand science.

So there's not one single thing that I do. And I'm interested also in the history of science and cosmology and the interactions between the arts and science. As a result I spend some time on programmes in arts and science, for example, as well.

Long ago, of course, all these different activities were the common interest to just about everybody active in science. They were part of "natural philosophy." But, as the centuries have gone by, science has become more specialized and more compartmentalized. Yet I've always been very keen to try to be as diverse as I possibly can. Especially as I think that there is a lot to be learned by considering the overlap regions between different disciplines, whether it's theology and science, humanities and science, history and science, philosophy and science, or one science and another.

I know there is one person here who participated in the Templeton-Cambridge Journalism Fellowships program last year and one who is doing so this year. The aim of that project is to try to raise the quality of reporting and discussion of matters on the interface of science and religion in various media and to give journalists an opportunity to spend time learning in detail about these issues, regardless of their personal religious views – if any. It can also help journalists create a new spectrum of contacts so they can find reliable information more quickly from scientists, philosophers, and theologians – to develop a community as scientists have done in these areas.

Q: You've been trying to create this dialogue between those in the fields of science and mathematics and a greater public audience, and there are many questions that will never be answered. Do you think that the scientists you deal with in many professional contexts are beginning to re-look at the question whether science has limits, and are they coming to understand some of the themes that you have addressed?

Prof. John Cornwell, Jesus College, Cambridge, John M. Templeton, Jr., and John Barrow at the Templeton Prize Luncheon Media Briefing.

A: We know science tells us that there are limits to what you can do and what you can know, because the universe appears to obey certain laws and constraints. And so there are things that you can't do by the very nature of that fact. But, in most sciences there is a fascinating historical development that goes a bit like this.

You hit on a successful theory, it makes lots of good predictions, it's successful, and it's validated by more observations. People start to become extraordinarily confident about its capability and they start to think that perhaps there's no question within its vocabulary that it will fail to answer. Then all of a sudden you run into a barrier: the theory itself predicts that it cannot predict, that it has a self-limiting quality.

A simple example is Einstein's relativity, where there is a cosmic speed limit for information transfer. Quantum mechanics reveals that there is also a conceptual limit on the types of information that can be obtained simultaneously by experiment, that you can't measure a position and a velocity simultaneously, or more deeply, that you can't define those concepts simultaneously with unprecedented precision. And in cosmology the effect of gravity's attraction is to predict that a singularity will form where you will eventually cease to be able to predict.

This seems to be a hallmark of our profound theories – they are not only limited, as are all forms of human knowledge and endeavour – but they are self-limiting. In mathematics, something like Gödel incompleteness, which we've just been celebrating in Vienna at the Gödel Centenary, is a profound example of the fact that even arithmetic possesses this self-limiting quality: that statements in the language of arithmetic exist which we can neither prove nor disprove using arithmetic.

We're used to not being able to do things because of practical or financial limitations, but science has given rise to fundamental limits that rise out of the nature of the knowledge of science itself. In cosmology we know that we're never going to be able to answer some of those great questions that you read about in *A Brief History of Time* and other popular books, like "did the Universe have a beginning?" or "is it infinite?" These questions are fundamentally unanswerable by science. Some cosmologists don't like that idea. But because the speed of light is finite, even if the Universe is infinite in spatial extent, we can only ever see and receive information from inside a finite horizon around us. And even if we had all the information about what was within that horizon we would only be able to decide whether the entire universe had a beginning or a particular type of origin. The whole Universe with a capital U, that "everything" there is – which might be infinite or might be finite, is beyond our reach. We can never determine whether it had a beginning or will have an end from the information that is available to us. That information is irreducibly incomplete because of the nature of reality, not because of any type of human fallibility. We have to start to do cosmology knowing that there is a certain incompleteness about what we can know, and our own position in the universe biases some of the evidence that we can gather.

In cosmology we know that we're never going to be able to answer some of those great questions that you read about... like "did the Universe have a beginning?" or "is it infinite?" These questions are fundamentally unanswerable by science.

It used to be, back in the 1980s, when Frank Tipler and I wrote our book *The Anthropic Cosmological Principle,* that you could always find a few skeptical philosophers who would say we can never be sure that the universe is the same beyond our horizon as it is inside it. But there was never any positive reason to expect that to be the case, it was just overly positivistic caution. However, as we argued even then, with the coming of things like the chaotic and eternal inflationary pictures of the universe, we now have positive reasons to expect that the universe is extremely different in structure beyond our physical horizon.

So, in the last ten years, we've come to appreciate that the astronomical universe is much more complex, much more diverse than we imagined. The old Copernican assumption that it's reasonable to assume that the universe is the same everywhere – so if you see a little bit of it then you know what's it like everywhere – wasn't a good assumption. The person who doesn't like this idea and feels that somehow science has to be able to answer every question that we can pose here and now, or that our knowledge has no limit to it, takes a rather anti-Copernican stance.

There's no reason why the universe should be constructed for our convenience. It would be extremely worrying to discover that all the questions that we could imagine about the fundamental structure of the universe just happened to be knowledgeable by us, using the experimental capabilities that we have now. We'd start to be suspicious that people were somehow framing the theories so that they were within reach only of current experiments. Just like in the late 1970s, the first theories that came out about proton decay were all enthusiastically predicting proton decay with a lifetime just at the sensitivity level of current experiments. Later, we realized that it's most likely the proton lifetime is billions of times longer.

Our universe is unusual because we can imagine universes that are much more complicated. Other solutions of Einstein's equations are vastly more complex and much more difficult to understand than the universe we see. So in cosmology in particular we've come to appreciate that there is incomplete knowledge because we can't manipulate the universe like a laboratory experimenter who can change the conditions and eliminate uncertainties step by step. In cosmology the universe is there, take it or leave it, and our view is inevitably biased. Some biases are easier to see than others; for instance, if you decide to do a survey to see what fraction of galaxies are bright and which are dim, it's always going to be over-represented by bright galaxies because they're easier to see.

Being an observational astronomer is very much about understanding these biases. Ideas like the so-called Anthropic Principle take consideration of that bias much deeper. They tell us that we have to try to understand all the ways in which there is a bias.

John Barrow with Martin Redfern of the BBC World Service at the Templeton Prize Luncheon Media Briefing.

So when we start to evaluate how likely it is that we should see a universe like we do, the "we" is important. The likelihood we are interested in is not an unconditional probability because there are all sorts of universes that we could possibly see. They might be the most likely ones in some fundamental sense but no matter how unlikely a life-supporting universe might be in the fundamental theory we would have to be in one. Failing to recognize this would lead us to wrongly rule out the theory because it didn't predict our universe as unconditionally likely.

Q: Following up on what you've been saying, John, the limits of cosmology, of science as referred to in cosmology, seem to be getting closer and closer to the limits in the dialogue between science and theology. I'm wondering if there's any way in which science can give a little ground, if you like, by changing subtly the way it's constructed, because even on the scale of cosmology, science is still essentially reductionist, it's entirely objective. And you said that it's a different world in psychology but I'm wondering if somehow personal experience, the things that one talks about in terms of theology, in terms of faith, for instance, can in some way be incorporated into cosmology?

A: You find that people have levels of belief about certain things in cosmology that dictate how they work. Suppose you have an issue like, does the universe have a beginning or not. This is a rather surprising idea, if you look historically at religions and philosophical thought in different cultures back to the earliest recorded times. It's not a common idea, yet we find it strangely sort of familiar because of our religious traditions.

But it's clear that there are some cosmologists who want to have a universe that has no beginning and some people want a universe with a beginning – and there are certainly some who just want *their* theory to be true. And you will find some people who regard the appearance of a physical infinity in the universe – that is, whether there could be an infinite density and temperature, as fundamentally impossible. You could actually use that principle as a guide to constructing your current theory. Indeed, string theory is accepted with such great enthusiasm by particle physicists because it predicts no physical infinities. If you are a particle physicist, you will think that infinity popping up in your theory is just a sign that it's provisional or it's wrong. If you work a bit harder you'll be able to remove that infinity and it will be just a very extreme but finite change.

But in cosmology, some people are willing to admit infinity at the beginning of the universe. Someone like Roger Penrose, for instance, regards it as absolutely essential that an infinite density and temperature exists there because otherwise there would be no arrow of time and the universe wouldn't know how to evolve. I'm not especially supporting one of these views but it's curious that you find these issues of whether things could be infinite or finite acting as guiding principles in cosmology and particle physics.

Issues about whether the universe can be infinite in size also give rise to all those unsavory paradoxes of infinite replication. Some people react to those very strongly and regard them as good enough reason why the universe has to be finite. So I think you find, in effect, people acting and doing their research on the basis of certain unproven, or even unprovable, principles.

Journalists may be in a better position to judge this question because you get to interview many scientists and cosmologists, on the same theme, and you get to see how differently they respond to the same questions.

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