



THE FAR-FUTURE UNIVERSE: Eschatology From A Cosmic Perspective

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PURPOSE

The dawn of the twenty-first century, when giant new telescopes are in use in Hawaii and Chile and powerful spaceprobes orbit the Earth, seems an appropriate time to gather and concentrate light on questions about the far-future of the universe. The scientists and theologians meeting in Rome, under the auspices of



Galileo Galilei
Portrait by Leoni Ottavio

the John Templeton Foundation, come together to explore eschatology from a cosmic perspective. The current theoretical prejudice is that our universe will still be expanding 100 billion years from now. But it is not clear whether it will be speeding up or slowing down. What are the various scenarios for the long-range future? What are the events on the path towards asymptopia? What would an eternal universe be like in each era between the present and the final "omega point"? Could our present space be converted catastrophically, perhaps by artificial intervention, into a new kind of space governed by different physical laws? Is there the possibility of influence from extra dimensions? Another set of questions involve the nature of complexity as a mathematical concept. What clues are provided by simple models such as "cellular automata" and "artificial life"? Are there limits to the amount of information storage in a decelerating as well as an accelerating universe? From the perspective of biology, we are compelled to ask: How large is the contingent element in evolution? We know that in about five billion years, the Sun will swell into a red giant and vaporize all life on Earth before it settles down into a slowly fading white dwarf. What are the scenarios and constraints for the future evolution of species now on Earth? For the development of some exotic form of intelligent life? And for its spread through the galaxy and beyond even after the stars have died? It is also important to consider whether we can construct a theology of the future universe. Can religious eschatology, which is concerned with the vindication of God's purposes for all creation, help draw the threads of these scientific speculations about "last things" together? What can a theology of hope tell us about the far-future cosmos that has relevance from a human perspective? Could the "death and raising of the universe," as Jürgen Moltmann has written, be "the prelude to an unexpected new creation of all things"? It seems clear that the lenses Galileo ground and polished nearly four hundred years ago to improve upon the Dutch "spyglass" have led us not only to successor optical instruments with their huge lightweight mirrors but to even more audacious questions than suggested by his "starry message."



CHAIR



Astronomer, Treatise on Astronomy, 14th century manuscript

One of the world's leading theoretical astrophysicists, **Martin J. Rees**, England's Astronomer Royal, was for many years the director of Cambridge University's famed Institute of Astronomy. Since 1992 he has been the Royal Society Research Professor at Cambridge and an official fellow at King's College, Cambridge. His contributions to our understanding of the origin and nature of the universe have been exceptionally broad-based. Two decades ago, he showed how the anthropic principle could be used to determine most of the fundamental constants of physics. He has added to our knowledge about the birth of stars and galaxies, demonstrated how deep-space quasars, the highly energetic cores of active galaxies seen through the Hubble Space Telescope, might be powered by massive black holes, and expounded theories that explain the mysterious explosions known as gamma-ray "bursters." A graduate of Cambridge, where he studied at Trinity College, he took an undergraduate degree in mathematics and earned a Ph.D. in theoretical astronomy in 1967. He was a fellow of Jesus College, Cambridge, a research fellow at California Institute of Technology, and a staff member of Cambridge University's Institute of Theoretical Astronomy before becoming a professor of astronomy at the University of Sussex in 1972. He returned to Cambridge the next year as Plumian Professor of Astronomy and Experimental Philosophy, a position from which he resigned in 1991 to devote more time to research and writing. Dr. Rees has lectured around the world and been a visiting professor at Caltech, Harvard, and the Institute for Advanced Study in Princeton, as well as a Regents Visiting Fellow at the Smithsonian Institution. He has served as president of the International Astronomical Union's Commission on High Energy Physics, the Royal Astronomical Society, and the

British Association for the Advancement of Science and is currently a trustee of the British Museum. A Fellow of the Royal Society, a Fellow of the Institute of Physics, and a Fellow of the Institute of Mathematics and Its Applications, he is a foreign honorary member of the American Academy of Arts and Sciences, a foreign associate of the U.S. National Academy of Sciences, an officer in the French Ordre des Arts et des Lettres, a foreign member of the American Philosophical Society, the Royal Swedish Academy of Sciences, and the Italian Accademia Nazionale dei Lincei, an honorary fellow of the Indian Academy of Sciences and of Jesus College and Trinity College, Cambridge, an honorary member of the Russian Academy of Sciences and the Norwegian Academy of Science and Letters, and a member of the Accademia Europaea and the Pontifical Academy of Sciences. Dr. Rees was knighted by Queen Elizabeth II in 1992. He has won a dozen major scientific prizes, including, most recently, the Bower Prize of Philadelphia's Franklin Institute, and holds honorary degrees from ten universities. A member of the editorial boards of a number of leading scientific journals, he has published some 450 research papers and three technical books. His first volume for a lay audience, *Before the Beginning* (1997), was both an overview of and meditation on what is known and what is merely conjectured about our universe in which he suggested that the universe we observe may be part of a "multiverse"—"just one element in an infinite ensemble: a cosmic archipelago." In his latest book, *Just Six Numbers: The Deep Forces That Shape the Universe* (Basic Books, 2000), Dr. Rees further explores the idea that the fundamental constants in the laws of physics have been finely tuned to allow for the emergence of complexity and consciousness and shows the profound and powerful connections between us and everything else.



PARTICIPANTS



Armillary sphere of 1564, used to map the stars and planets.

John D. Barrow is a research professor of mathematical sciences at Cambridge University where he leads the Millennium Mathematics Project, a new initiative to improve public understanding and appreciation of mathematics and its applications. His research interests are in mathematical and physical cosmology, the interaction between particle physics and cosmology, the constants of physics, and theories of gravity. A graduate of the University of Durham, he took first-class honors in mathematics and went on to earn a D.Phil. in astrophysics at Oxford University in 1977. He did post-graduate work in astronomy as a Lindemann Fellow at the University of California, Berkeley and subsequently held a junior research lectureship at Christ Church, Oxford and in the University's department of astrophysics. He returned to Berkeley as a Miller Fellow before joining the astronomy faculty of the University of Sussex as a lecturer in 1981. Named a full professor and acting director of the University's Astronomy Centre eight years later, Dr. Barrow was appointed the Centre's director in 1995, a post he held until taking up his Cambridge appointment last year. He is the recipient of many awards, including the Samuel Locker Award in Astronomy and the 1999 Kelvin Medal of the Royal Glasgow Philosophical Society. While at Sussex, Dr. Barrow held Nuffield and Leverhulme Fellowships and a five-year Senior Research Fellowship awarded by the Particle Physics and Astronomy Research Council of the United Kingdom. He has been the Gordon Godfrey Visiting Professor of Physics at the University of New South Wales in Sydney and holds an honorary degree from the University of Hertfordshire. Among the numerous named lectures he has delivered are the Gifford Lectures at Glasgow University, the George Darwin Lecture of the Royal Astronomical Society (RAS), the Amnesty International Lecture on Science in Oxford, the Spinoza Lecture at the University of Amsterdam, the Flamsteed Lecture, and the Royal Society of Arts Christmas Lecture for Children. He also has lectured at the Venice Film Festival, 10 Downing Street, and Windsor Castle. Dr. Barrow is a fellow of the RAS and a corresponding member of the L'Academie Internationale de Philosophie des Sciences. A prolific writer, he has published some 300 scientific articles in cosmology and astrophysics, edited three books, and is the author or co-author of twelve others that explore the wider historical, philosophical, and cultural ramifications of developments in astronomy. His most recent book, *The Book of Nothing*, was published by Random House in October.



A well-known expert on the theory of games, **Steven J. Brams** is a professor of politics at New York University. He has applied his principles for dealing with situations where two or more players are in competition with one another not only to conflicts in labor relations, domestic politics, and international affairs, but also to theological issues. A graduate of Massachusetts Institute of Technology, Dr. Brams received his Ph.D. in political science from Northwestern University in 1966. He was a research associate at the Institute for Defense Analysis and an assistant professor at Syracuse University before joining the NYU faculty in 1973. He has held visiting appointments at the University of Michigan, the University of Rochester, the Institute for Advanced Studies in Vienna, the University of California, Irvine, the University of Haifa, and Yale University. Dr. Bram's work has been supported by the Social Science Research Council, the Guggenheim Foundation, the American Association for the Advancement of Science, the Public Choice Society, the Ford Foundation, the United States-Israel Binational Science Foundation, the Sloan Foundation, the United States Institute of Peace, the National Science Foundation, and the Russell Sage Foundation. He has published some 200 research papers and is the co-editor of two books and the author or co-author of 13 others. His most recent book (with Alan D. Taylor), *The Win-Win Solution: Guaranteeing Fair Shares to Everybody* (W.W. Norton, 1999), is a blueprint for getting to "yes" in conflict negotiation.



A. Graham Cairns-Smith, honorary senior research fellow at the University of Glasgow, is a chemist who has devoted much of his professional life to the study of very early evolution and has written extensively on the origins of life and the origins of consciousness. He is also a painter. Educated at Kilmarnock Academy and Fettes College in his native Scotland, he earned a Ph.D. in synthetic and solid state organic chemistry at the University of Edinburgh in 1957. Dr. Cairns-Smith then joined the Glasgow faculty where he taught for forty years. As a reader in chemistry, he not only gave classes in organic chemistry but also in molecular biology and the philosophy of science. He has lectured widely in Britain and abroad. A Fellow of the Royal Society of Edinburgh, Dr. Cairns-Smith is also a Fellow of the Institute of Biology and a Fellow of the International Society for the Study of the Origin of Life. He is the author of numerous research papers on a variety of scientific topics and has published six books on science for the general public. *The Life Puzzle* (1971) was the first to reflect his ideas on the possibility that clay crystals were components of the first organisms on Earth. His *Genetic Takeover: And the Mineral Origins of Life* (1982) developed further his radical view of early evolution, which suggests that present biochemical arrangements were made possible by the evolution of a low-tech precursor. *Evolving the Mind* (1998), Dr. Cairns-Smith's first full-length study of the origin of consciousness, was widely hailed for its lucidity in explicating the ingenuity of cellular design and operation. He followed it with *Secrets of the Mind* (Springer-Verlag, 1999), his most recent volume, which considers how conscious states can affect behavior. Dr. Cairns-Smith is currently completing a new book-length manuscript on the nature of science, which he calls "Science Magic: Stories about Science and the Making of Super Human Intelligence."

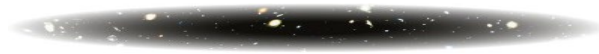


Philosopher **Stephen R. L. Clark** has had a long-standing interest in both religion and science fiction. In his 1993 book, *How to Live Forever*, he makes the genre sound a lot like theology. Finding immortality an abiding theme in science fiction, he examines the ways in which science-fiction writers have imagined it with a view to showing that important resources can be found in science fiction for philosophical explorations of the possibilities of unending existence. "Much of the intelligible universe is quite unintelligible to us," he tells readers, and reminds them of William Blake's observation that "what is now proved ... was once only imagined" and "what is now clearly imagined was once only a sense of something missing." A resident of the Wirral Peninsula near Liverpool, Dr. Clark studied at Balliol College, Oxford. He took first-class honors in classics, continued his studies as a fellow of All Souls College, and received a Ph.D. in philosophy from Oxford in 1973. He was a lecturer in moral philosophy at the University of Glasgow for nine years, and in 1984, he was appointed professor of philosophy at the University of Liverpool, where he now chairs the department. He has been a visiting professor at Vanderbilt University and held an Alan Richardson Fellowship at Durham University. Among many invited lectures, he has delivered the Gifford Lecture at Glasgow, the Stanton Lecture at Cambridge, the Wilde Lecture and the Aquinas Lecture at Oxford, the Read Tuckwell Lecture at Bristol University, the Scott

Holland Lecture at Liverpool, the Royal Institute of Philosophy Lecture at Durham University, and the Aquinas Lecture at the Catholic University of Leuven. He has been chief editor of the *Journal of Applied Philosophy* since 1990, as well as serving as a member of the editorial board of the Cambridge University Press series entitled *New Studies in Christian Ethics*. The author of more than fifty scholarly articles, he has contributed chapters to some sixty books in addition to editing one book and writing nine others. His work on the proper understanding and treatment animals, most recently *Animals and their Moral Standing* (1997), and of the living earth, notably *How to Think about the Earth: Models of Environmental Theology* (1993), have brought him international acclaim. In addition, he is well known for his studies of the significance of our animal natures for our lives as political and social beings, which were summarized in *The Political Animal* (1999), and for his work on Christian theism and human freedom, particularly *God, Religion and Reality* (1998). His most recent book is *Biology and Christian Ethics*, which will be published later this year by Cambridge University Press. Dr. Clark is currently writing about alien intelligence from the perspective of science fiction and philosophy.




Professor of evolutionary paleobiology at Cambridge University, **Simon Conway Morris** has devoted his research life to the study of the 520-million-year-old Burgess Shale, found between two peaks in the Canadian Rockies, and related fossil-rich formations. In his most recent book, *The Crucible of Creation* (1998, Oxford University Press), he re-interprets the soft-body fauna found in fissile rock as evincing the preeminent role of convergence in evolution. His demonstration that many of the fantastic Burgess Shale animals are related, albeit remotely, to modern forms supports the theory that similar solutions are found to the same kind of environmental challenges in independent lines and places and impugns as seriously incomplete the reductionist viewpoint that the present-day world arises as the result of chance past events. A graduate of the University of Bristol, where he took first-class honors in geology, Dr. Conway Morris went on to Cambridge and studied at Churchill College with Harry Whittington, the first re-interpreter of the Burgess Shale, on a Natural Environment Research Council (NERC) Studentship. He was elected a research fellow of St. John's College in 1975 and received his Ph.D. in evolutionary paleobiology the next year. Appointed a lecturer in earth sciences at The Open University in 1979, he returned to Cambridge as a lecturer four years later and was promoted to his current chair in 1995. Dr. Conway Morris is a fellow of the Royal Society. He has held research grants from the society as well as from the Nuffield Foundation, the Carlsberg Foundation, the NERC, National Geographic Society, and the Leverhulme Foundation. He has delivered numerous invited lectures throughout the United Kingdom, Europe, Asia, Canada, and the United States and is the author of some ninety research papers. Dr. Conway Morris has served as editor of five books. The first version of his study of the Burgess Shale and the rise of animals, *Journey to the Cambrian* (1997), was printed in Japanese and has been re-printed seven times. He contributes frequently to general magazines and encyclopedias and to radio and television programs on science.




George V. Coyne, S. J. is the director of the Vatican Observatory. Long before the National Aeronautics and Space Administration (NASA) introduced its Ranger and Apollo programs, he studied the lunar surface, and his broadly-based research interests also included the birth of stars. He was one of the pioneers in the use of a special technique, known as polarimetry, as a powerful tool for astronomical investigation. He is currently studying cataclysmic variable stars, that is, binary stars where one super-dense star is capturing matter from its companion, and searching for protoplanetary disks in the vicinity of young stars. An abiding and parallel fascination with the interrelationship of science and religion led him to found a series of studies concerning controversies about Galileo, entitled *Studi Galileiani*, and to organize several conferences around the theme "Scientific Perspectives On Divine Action." A graduate of Fordham University, where he majored in mathematics and earned his licentiate in philosophy, he received his Ph.D. in astronomy from Georgetown University in 1962 and a licentiate in theology from Woodstock College in 1966. Dr. Coyne joined the Vatican Observatory as an astronomer in 1969 and the next year began teaching in the Lunar and Planetary Laboratory of the University of Arizona. He was named a senior research fellow at Arizona in 1976 and, in 1977, the director of its Catalina Observatory and associate director of the Lunar and Planetary Laboratory. He became associate director of the Arizona Observatories in 1978, the same year he was appointed to his Vatican Observatory post, and, in 1979, served as acting director. Dr. Coyne holds honorary degrees from St. Peter's University (Jersey

City) and Loyola University (Chicago) in the United States, the University of Padua, and the Pontifical Theological Academy of Jagellonian University in Cracow. He has published more than one hundred scientific papers and edited a number of books.



A British theoretical physicist, based in Australia, **Paul Davies** is the author of more than twenty-five books. He obtained a doctorate from University College, London in 1970 and was a research fellow at the Institute of Theoretical Astronomy in Cambridge until 1972, when he was appointed lecturer in mathematics at King's College, London. In 1980, he was offered the chair of theoretical physics at the University of Newcastle-upon-Tyne, a post that he held until moving to Australia in 1990, first as professor of mathematical physics at the University of Adelaide and then as professor of natural philosophy until 1996. He is currently visiting professor of physics at Imperial College, London. Dr. Davies's research has been mainly in the field of quantum gravity and cosmology, topics on which he has published more than 100 scientific papers. His books, *The Physics of Time Asymmetry* (1974) and *Quantum Fields in Curved Space* (1981), written with former student Nicholas Birrell, remain standard texts for researchers. He has made several important contributions to the theory of black holes and cosmological models. His interests, however, extend much more widely, ranging from particle physics to astrobiology to complexity theory. For many years he has explored the philosophical consequences of the latest ideas at the forefront of research, work for which he won the 1995 Templeton Prize for Progress in Religion. Dr. Davies has a strong commitment to bringing science, and its deeper implications, to the wider public. In addition to research and writing that has led to his best-selling books, he makes almost daily media appearances and contributes regularly to newspapers and journals around the world. He was for several years a columnist for *The Economist* and *The Australian*. He devised and presented a highly successful series of science documentaries on BBC Radio 3, two of which were published in book form as *The Ghost in the Atom* (1986) and *Superstrings: A Theory of Everything?* (1988). Recently his two television series, "The Big Questions" and "More Big Questions", won critical acclaim when screened on Australia's SBS channel. In the UK, Dr. Davies's Templeton Prize was the subject of an Equinox documentary on Channel 4, and three years ago an entire episode of Border Television's series "The Beatitudes" was devoted to an interview with him on science and the meaning of life. Dr. Davies is a fellow of the Institute of Physics, the Australian Institute of Physics, The World Economic Forum, and the World Academy of Arts and Science. He is a consultant to several publishers, as well as a number of scientific and cultural organizations in the UK and Australia. His most recent book, *The Fifth Miracle: The Search for the Origin of Life*, was published by The Penguin Press and Simon & Schuster in 1998. In it, he examines the state of our knowledge about information-based complexity, argues that science also must account for the source of biological information, and suggests that emergent laws of complexity offer reasonable hope for better understanding not only of biogenesis but also of biological evolution.



G **George F. Rayner Ellis** is as widely respected for his anti-apartheid Quaker activism as for his contributions to cosmology. Born in Johannesburg, South Africa and educated in Natal and Cape Town, he received his Ph.D. in applied mathematics and theoretical physics from Cambridge University in 1964 and has taught in both fields on three continents. For the past decade, he has been a professor of applied mathematics at the University of Cape Town while lecturing throughout the world. Dr. Ellis has served as president of the Royal Society of South Africa and of the International Society of General Relativity and Gravitation. His scientific work on the mathematical foundations of general relativity and cosmology is recognized for its depth, originality, and wit. He studies fundamental questions like the geometrical structure of the universe and is not afraid to challenge conventional assumptions about how our universe began and is built. In his alternative model to the violent Big Bang, the Whimper model, all starts with Quaker gentleness. In the bleak South Africa of the 1970's and 1980's, Dr. Ellis used knowledge both as a weapon and a shield against violence and injustice. During the past decade, he has been deeply involved in race relations, housing policy, and the future of the scientific enterprise of his country. He is a Fellow of the Royal Astronomical Society and the Institute of Mathematics and its Applications, and among the prizes he has won are the Herschel Medal of the Royal Society of South Africa, the Claude Harris Leon Foundation Achievement Award, the Gold Medal of the South African Association for the Advancement of Science, and the Star of South Africa Medal, which was presented to him in 1999 by President Nelson Mandela. Dr. Ellis holds an honorary degree from Haverford College. Co-author with

Stephen W. Hawking of *The Large Scale Structure of Space Time* (1973), his more than 200 scientific papers and eight major books reflect the rigor of his mind and the depth of his moral understanding. His latest studies are (with Peter Coles) *Is the Universe Open or Closed? The Density of Matter in the Universe* (Cambridge University Press, 1996) and (with Nancey Murphy) *On the Moral Nature of the Universe* (Fortress Press, 1996).



A professor of philosophy at the Pontifical Academy of Theology in Cracow, Poland, **Michael Heller** is an adjunct member of the Vatican Observatory staff. He also serves as a lecturer in the philosophy of science and logic at the Theological Institute in Tarnow. A Roman Catholic priest, Dr. Heller was ordained in 1959. He was graduated from the University of Lublin where he earned a master's degree in philosophy in 1965 and a Ph.D. in cosmology in 1966. After beginning his teaching career at Tarnow, he joined the faculty of the Pontifical Academy of Theology in 1972 and was appointed to a full professorship in 1985. The recipient of an honorary degree from the Technical University in Cracow, he has been a visiting professor at the Catholic University of Louvain in Belgium and a visiting scientist at Belgium's Liège University, Oxford University, Leicester University, Ruhr University in Germany, The Catholic University of America, and the University of Arizona among others. Dr. Heller is a member of the Pontifical Academy of Sciences. His current research is concerned with the singularity problem in relativistic cosmology and the use of noncommutative geometry in seeking the unification of general relativity and quantum mechanics. He has published nearly 200 scientific papers not only in general relativity and relativistic cosmology but also in philosophy and the history of science and science and theology and is the author of more than 20 books. In his most recent volume, *Is Physics an Art?* (Biblos, 1998), he writes about mathematics as the language of science and also explores such humanistic issues as beauty as a criterion of truth, creativity, and transcendence.



Lawrence M. Krauss, no biographical information available.



A twenty-year old prisoner of war interned in England when he began his study of theology and philosophy, **Jürgen Moltmann** has become one of the most respected theologians of our time. For the past thirty years, he has been engaged in a profound exploration of the meaning of divine suffering and the unique role of the Cross in disclosing the nature of God. His work draws not only on the great theological tradition of Luther and Barth, but also on his experience as a pastor in post-war Germany. After completing his doctorate in theology at Göttingen University in 1952, he served the Protestant Church in Bremen for five years. In 1958, he became a professor of theology in a Protestant seminary in the Rhineland city of Wuppertal, and in 1963 he accepted the chairmanship of the department of systematic theology and social ethics at the University of Bonn. Named professor of systematic theology on the Protestant Faculty of the University of Tübingen in 1967, Dr. Moltmann became professor emeritus in 1994. As a visiting professor, he has taught all over the world. He is the recipient of prizes in literature, philosophy, and theology and holds honorary degrees from Raday College in Budapest, St. Andrews University, the Catholic University of Louvain in Belgium, and the University of Iasi in Rumania, as well as Emory University, Duke University, Bethlehem Theological Seminary, and Kalamazoo College in the United States. In addition to his monumental study, *The Crucified God* (1974), Dr. Moltmann's most influential works include his reflections on eschatology (*Theology of Hope*, 1967) and on a Trinity deeply involved in and affected by the world (*The Trinity and the Kingdom of God*, 1981). His latest book is *The Coming of God* (Augsburg Fortress, 1997).



Hubert Reeves is a director of research at the Centre National de la Recherche Scientifique in Paris. Specializing in nuclear astrophysics, he is an expert on the origins of light elements and a well-known

science educator who appears frequently on French television. Dr. Reeves is also highly regarded for his environmental work and has written extensively on ecological issues. A native of Canada, he is a graduate of Jean-de-Brébeuf College and the University of Montreal. He began his graduate work at McGill University, where he took a master of science degree in 1955, and went on to earn a Ph.D. in astrophysics at Cornell in 1960. He returned to the University of Montreal as a member of the physics faculty and was, at the same time, a scientific advisor to National Aeronautics and Space Administration in the United States. In 1964, he went to Belgium as a visiting professor at the University of Brussels, and in 1965, he was named research director of France's national center for scientific research and an affiliate of the French Atomic Energy Commission in Saclay. For the past thirty-five years, Dr. Reeves has continued to teach cosmology for a month each year at the University of Montreal, where he is an associate professor of physics. The French government has honored him for his successful popularization of science by naming him a chevalier of the Order of Merit. He is also a chevalier of the French Legion of Honor, an officer of the Order of Canada, and a recipient of the Prix de la Fondation de France. The author of some 100 scientific papers, Dr. Reeves has published more than ten books, including the bestsellers *Atoms of Silence* (1985), *The Hour of Our Delight* (1990), and, most recently, *Origins: Speculations on the Cosmos, Earth, and Mankind*, which was published by Arcade (New York) in 1997 and brought out in a paperback edition last year.



The founding director of The Center for Theology and the Natural Sciences (CTNS) in Berkeley, California, **Robert J. Russell** is a professor of theology and science in residence at The Graduate Theological Union in Berkeley. He is an ordained minister in the United Church of Christ and has been a leader in the enterprise of promoting dialogue between scientists and theologians for the past several decades. A graduate of Stanford University, he holds a master's degree in physics from the University of California, Los Angeles, a bachelor of divinity degree, *magna cum laude*, and a master of theology degree, both from The Graduate Theological Union. He received a Ph.D. in physics from the University of California, Santa Cruz in 1978. Dr. Russell began his teaching career as an assistant professor of physics at Carleton College where he was also a pastoral associate. He returned to California as an adjunct visiting professor at The Jesuit School of Theology, Berkeley, in 1981, the year he founded CTNS. Appointed an assistant professor at The Graduate Theological Union in 1982, he became a professor in residence nine years later. Dr. Russell also serves as an associate of the Chicago Center for Religion and Science. He has delivered numerous invited lectures and organized some twenty-five national and international symposia on the subject of science and religion. He recently served as a judge for the Templeton Prize for Progress in Religion. The founding editor of the CTNS *Bulletin*, he previously served as book review editor of *Zygon* and currently serves as general editor of *Scientific Perspectives on Divine Action*, a series published jointly by CTNS and the Vatican Observatory. He is a member of the *Zygon* editorial advisory board and the board of editorial advisors of the Fortress Press series, *Theology and the Sciences*, as well as a consultant to the Committee on Technology and Values of the National Conference of Catholic Bishops. The author of a dozen physics papers published in scientific journals and nearly thirty articles on science and religion, Dr. Russell is the co-editor of six books, including *Chaos and Complexity* (1995), which won a Templeton Prize for Outstanding Books in Theology and Science. He has contributed some twenty chapters to collected volumes and with the support of a Templeton research grant is currently preparing a book-length manuscript entitled "Time in Eternity: Eschatology and Cosmology in Mutual Interaction."



Lee Smolin is a theoretical physicist who has made significant contributions to the search for a quantum theory of gravity. A professor of physics at the Center for Gravitational Physics and Geometry at Pennsylvania State University and, currently, a visiting professor at Imperial College, London, he is one of a small number of scientists actively seeking to reconcile—or "unify"—general relativity, Einstein's theory of gravity, and quantum mechanics, the prevailing theory of matter and motion developed in the 1920's. Among his most fruitful ideas is the loop formation of quantum gravity, which he developed with Carlo Rovelli and other physicists. It led to the prediction that space has a certain discrete or atomic structure at very small distances. He also has worked on cosmology and, in particular, proposed a hypothesis called "cosmological natural selection," in which Darwinian principles of evolution are applied to the universe, providing a possible explanation for some of the properties of the elementary particles

and forces. His conjecture is that our universe forms part of an infinite chain of self-reproducing universes whose physical laws evolve through natural processes of self-organization. The black holes created by collapsing stars lead to the creation of new regions of space and time. These events resemble the big bang, and, indeed, the big bang in our past is assumed to be one such event. Dr. Smolin has hypothesized that the daughter worlds that emerge from "dark stars" may differ in small, random ways from their parents. But if, and to the extent, that changes of even the slightest degree affected the production of black holes, evolutionary pressure would favor universes with many of them. Dr. Smolin began his studies in physics at Hampshire College, where he majored in natural philosophy, and then went on to Harvard University, where he earned his Ph.D. in theoretical physics in 1979. After post-doctoral work at the Institute for Advanced Study in Princeton, the Institute for Theoretical Physics at the University of California, Santa Barbara, and the University of Chicago, he joined the Yale faculty as an assistant professor of physics in 1984, and in 1988, he became an associate and then a full professor of physics at Syracuse University before accepting his current position at Penn State five years ago. He has been a visiting scientist at more than a dozen universities and institutes and given some fifty invited lectures to scientific audiences. Much of Dr. Smolin's research has been supported by grants from the National Science Foundation, and he also has won awards from Syracuse and the Gravity Research Foundation in addition to a number of travel fellowships. The author of more than eighty scientific papers, he attracted widespread public attention for *The Life of the Cosmos* (1997) in which he used arguments, drawn from both science and philosophy, to examine the consequences of his proposal that the laws of nature are, in part, the result of processes analogous to natural selection. His latest book, *Three Roads to Quantum Gravity* (Basic Books and Weidenfeld and Nicolson, 2000), reports on recent progress towards a quantum theory of gravity.



Regius Professor of Divinity at Oxford University, **Keith Ward** is one of Britain's foremost writers on Christian belief and doctrine in the light of modern scientific discoveries and in the context of other faith traditions. He has explored the tensions between the classical tradition of natural theology, with its atemporal and self-sufficient God, and the Biblical idea of a creative and responsive God, critically examined recent secular theories of human nature that have led to what he perceives as a subtly misconceived attack on the idea of the soul, compared the place of revelation and concept of creation in the major world religions, and sketched a revised Christian vision that looks to a convergent global spirituality. A graduate of the University of Wales, where he took a first-class honors degree in 1962, he holds a B. Litt. from Oxford and an M.A. and doctorate in divinity from both Oxford and Cambridge Universities. He has been a lecturer at the University of Glasgow, St. Andrews University, and King's College, London. Elected a fellow and named dean and director of studies in philosophy and in theology at Trinity Hall, Cambridge, in 1976, he was appointed F. D. Maurice Professor of Moral and Social Theology at the University of London in 1986 and subsequently professor of the history and philosophy of religion, a position he held for five years before returning to Oxford in 1991. He has been a visiting professor at Drake University and at the Claremont Graduate School and lectured in India and New Zealand as well as throughout the United Kingdom. Ordained a priest in the Church of England in 1972, he has been canon of Christ Church, Oxford, for the past seven years and is a member of the Council of the Institute of Philosophy and of the Academic Advisory Board of the Oxford Centre for Islamic Studies. Professor Ward formerly served as joint editor of *Religious Studies*. The author of numerous works on theology and philosophy, he has just completed a four-volume comparative theology, the final volume of which is *Religion and Community* (Clarendon Press, 2000).





Armillary sphere of 1564, used to map the stars and planets.

**The telescope is "more precious than any scepter".
—Johannes Kepler**

**"I want [young men sent through universities] to see that just as Nature has given to them, as well as to philosophers, eyes with which to see her works, so she has also given them brains capable of penetrating and understanding them."
—Galileo Galilei**

**"It would be excessive boldness for anyone to limit and restrict the Divine power and wisdom to some particular fancy of his own."
—Galileo Galilei**

The Humble Approach Initiative

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