



THE
HUMBLE
APPROACH
INITIATIVE



PURPOSE IN EVOLUTION: Is Convergence Sufficiently Ubiquitous to Give a Directional Sign?

A symposium sponsored by the John Templeton Foundation

24, 25, and 26 June 2004

Vatican Observatory. Castel Gandolfo, Italy



Contact: Mary Ann Meyers, Ph.D., Senior Fellow

PURPOSE

LAKE TANGANYIKA SPECIES



Julidochromis ornatus



Tropheus brichardi



Bathybates ferox



Cyphotilapia frontosa



Loboichilotes labiatus

LAKE MALAWI SPECIES

The exploration of issues of evolution in the context of possible evidence for constraints imposed by a deeper structure is being undertaken in full cognizance of the prevailing paradigm amongst biologists that evolution is ungoverned by general principles or laws. The normative position does not maintain that evolution is free of physical principles, such as gravity, Reynolds numbers, or the four-power law of fluid-flow in pipes, but apart from the broad envelope of physico-chemical constraints, biologists generally hold that everything (or nearly everything) that has evolved is, in the final analysis, the result of random processes. Put crudely, the widely accepted scientific worldview is that human beings or any other product of evolutionary diversification is accidental and, by implication, incidental. Add the sheer diversity of the biosphere (both past and present) and the random nature of mutations to the occasional environmental disruption, be it bolide impact, snowball Earth, or sudden greenhouse, and the overwhelming impression is of an evolutionary process that could have gone in a myriad of separate directions.

In one sense, of course, evolution is predictable in that, for all intents and purposes, it is the result of Darwinian mechanisms. So far as there is an over-arching principle, it is that to the first approximation organisms are adapted to their environment. But even this notion has been challenged in various respects, and the role of exaptation and spandrels has received considerable (if, perhaps, undue) attention. One counterpoint to such a frankly anti-adaptionist program is the investigation of possible optimal states and the related theme of symmorphosis—the concept that structural design is very well matched to function. But at present these investigations suffer from a concentration on vertebrate model systems and a reluctance to adopt an integrated approach that could move beyond the admittedly important areas of physiology and biomechanics. It seems that a coherent approach to the origin and evolution of adaptive complexes, not only in terms of classical functional morphology but also across all levels of biology (from proteins to societies), is also lacking. The effectiveness and integration of biological systems is little less than startling. Yet in scientific circles, there is a very deep-seated



Melanochromis auratus



Pseudotropheus microstoma



Ramphochromis longiceps



Cyrtocara moorei



Placidochromis milomo

ABOVE: Distantly-related cichlids from Lake Tanganyika in West Africa and Lake Malawi in East Africa have evolved to become uncannily alike. The fish demonstrate how morphological resemblance may have little correlation with genetic closeness or evolutionary lineage (phylogenetic relationship). It appears that evolution repeatedly discovers the same solutions to the same ecological challenges.

TOP of PAGE: Castel Gandolfo, the God-haunted landscape that George Innes painted in 1876, features Lake Albano and, in the upper right corner, the papal summer residence surrounded by a tall wall. Immersed in the ideas of the religious thinker Emanuel Swedenborg, Innes uses soft light to convey a diffuse sense of the human spirit. The lake and the surrounding hills appear as interlocked geometric segments of nature as if to reveal a hidden unity. In the catalog for the 2003 National Academy of Design exhibition, "George Innes and the Visionary Landscape," Andrienne Baxter Bell speculates that the painting captures the artist's desire "to create a new pictorial expression of nature's divine order."

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Helen Thurston Ayer Fund.

distrust of teleological language, even though researchers may occasionally use the word "design" in an attempt to grapple with the often astonishing adaptive complexes they study.

The purpose of this symposium is not to dispute the orthodox model, but to inquire whether it is sufficient and, if it is not, to consider what we need to know and ultimately how we might discover the requisite information with one or more research programs. The thirteen participants, scientists, philosophers, and theologians, who gather at the Vatican Observatory, are focusing on seven clusters of questions:

Can we speak of a universal biochemistry? Are there viable alternatives, and do "decisions" at key points then pre-determine further evolutionary stages in a particular direction? If these "key points" do exist, how do we define them? Are there genuine "frozen accidents" of evolution? Are pre-biotic circumstances incidental, or central, to subsequent organic development?

How do levels of complexity emerge, and are they inevitable? Can we envisage other types of complexity? Will any biosphere show features such as endosymbiosis, multicellularity (or indeed cells!), communication (including quorum sensing), ecological guilds, nervous systems, and societies? If so, are those on Earth of any wider significance?

Can we properly define evolutionary constraints? Can we envisage genuine alternatives at any level of evolution? Do "decisions" at one level predispose evolution in particular directions? What is the role of evolutionary incumbency? Is it correct that any biosphere will be utterly unlike any other that exists? In other words, how are biological "hyperspaces" to be "navigated"?

What does convergence tell us about evolution? How do we define convergence? How variable are evolutionary trajectories leading to similar outcomes? Is convergence at molecular levels significant? Are developmental pathways convergent? Does convergence at one biological level depend on convergence at another?

How do we explain integrated adaptive units? Is symmorphosis a viable concept? Does concerted convergence have a general applicability? Is specialization always a "dead-end"? Are there general rules concerning the invasion of new adaptive zones?

What do we mean by intelligence? Is intelligence an inevitable product of evolution? How many alternatives are there? Can we define an intelligence "space"? Is intelligence necessarily neural? Do particular intelligences have necessary co-adaptations?

Is there a deep structure to biological systems? If there is, or potentially if we have reason to believe so, where do we go from here? Is a landscape metaphor redundant? How can we model hyper-dimensional biological spaces? Are there inevitable end-points? Are there optimal systems?

The conversation amongst the participants is taking place under the aegis of the John Templeton Foundation. Our local host is the Rev. Dr. George V. Coyne, S.J. The observatory he directs is on the grounds of Villa Barberini, the papal summer residence in Castel Gandolfo, a town in the Alban Hills southeast of Rome.

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APPROACH

The symposium is part of the Templeton Foundation's *Humble Approach Initiative*. The goal of the initiative is to bring about the discovery of new spiritual information by furthering high-quality scientific research. The "humble approach" is inherently interdisciplinary, sensitive to nuance, and biased in favor of building linkages and connections. It assumes an openness to new ideas and a willingness to experiment. Placing high value upon patience and perseverance, it retains a sense of wondering expectation because it recognizes, in Loren Eisley's haunting phrase, "a constant emergent novelty in nature that does not lie totally behind us, or we would not be where we are." A fundamental principle of the Foundation, in the words of its founder, is that "humility is a gateway to greater understanding and open[s] the doors to progress" in all endeavors. Sir John Templeton believes that in their quest to comprehend foundational realities, scientists, philosophers, and theologians have much to learn about and from one another. The humble approach is intended as a corrective to parochialism. It encourages discovery and seeks to accelerate its pace.



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CHAIR

Simon Conway Morris is widely acknowledged as one of the foremost paleontologists of his time. A professor of evolutionary paleobiology at Cambridge University, he has devoted his research career 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 acclaimed 1998 study, *The Crucible of Creation*, he re-interpreted the soft-body fauna found in fissile rock as evincing the pre-eminent 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. In his most recent book, *Life's Solution: Inevitable Humans in a Lonely Universe* (Cambridge University Press, 2003), he extends his argument and builds his case for the inevitability of numerous evolutionary outcomes on a foundation laid by Charles Darwin himself in *Origin of the Species*, the epochal work to which critics have compared *Life's Solution*. Dr. Conway Morris concludes that large-scale features of the history of evolution "are congruent with a Creation"—and he helps restore humanity's place at its center by his insistence that intelligence is not a fluke, though a life-friendly planet like Earth may be unique. 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 and serves on the board of advisors of the John Templeton Foundation. His work has been supported by research grants from the Society as well as from the Nuffield Foundation, the Carlsberg Foundation, the NERC, the National Geographic Society, and the Leverhulme Foundation. He has delivered numerous invited lectures throughout the

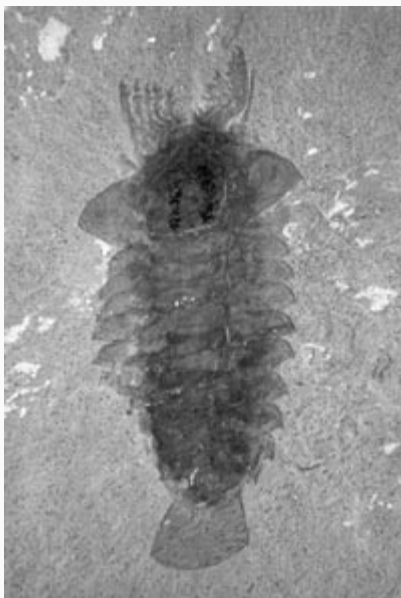
United Kingdom, Europe, Asia, Canada, and the United States. He contributes frequently to general magazines and encyclopedias and to radio and television programs on science. The author of some ninety research papers, Dr. Conway Morris has served as editor of five books. The first version of his study of the Burgess Shale and the rise of animals, *Journey to the Cambrian* (1997), was printed in Japanese and has been reprinted seven times.

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Credit: D.H. Collins.

The fossils of the Burgess Shale quarry are a window on our past. The soft-bodied organisms preserved there, like the



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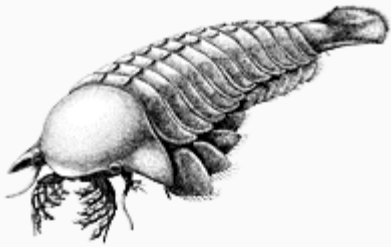


PARTICIPANTS

Contact: Mary Ann Meyers, Ph.D., Senior Fellow

A reader in comparative cognition at Cambridge University, **Nicola S. Clayton** specializes in animal cognition. She works at the interface between ethology, experimental psychology, and neuroscience. Her research is currently focused upon whether food-storing animals, especially birds and rodents, can plan for the future as well as recall past events. She also is analyzing the complex cognitive strategies used by some birds to protect their hidden food stores from potential thieves. Educated at Pembroke College, Oxford, where she was a Domus Scholar and took an honors degree in zoology, Dr. Clayton earned a Ph.D. in bird song at St. Andrew's University in 1987. She studied at the University of Bielefeld in Germany on an Alexander von Humboldt Scholarship and a Royal Society Post-doctoral Fellowship, and she then held a SERC Post-doctoral Fellowship and a Linacre College Junior Research Fellowship at Oxford University followed by a ten-year AFRC University Research Fellowship in Oxford's zoology department. Dr. Clayton joined the faculty of the University of California, Davis, as an assistant professor of neuroscience, physiology, and behavior in 1995 and was named chair of the Animal Behavior Graduate Group in 1999 and a full professor in 2000. Returning to England later that year, she was appointed a tenured university lecturer in the Department of Experimental Psychology at Cambridge and named to her present position in 2002. For the past four years, she also has served as a tutor and director of studies in natural sciences at Clare College, Cambridge. Her research has been supported by grants from British and American government agencies as well as from private foundations. Dr. Clayton was formerly a consulting editor for *Animal Behaviour* and *Behavioural Neurosciences* and an associate editor of the *Journal of Ethology*. She currently serves as an associate editor of *Animal Behaviour*, *Ibis*, *Learning and Motivation*, and the *Quarterly Journal of Experimental Psychology*, as well as on the editorial committee for *Biological Reviews*. A frequent contributor to radio and television programs on science, Dr. Clayton has published more than 100 papers in scientific journals and volumes of collected works.

Sanctacaris pictured above, is from the middle Cambrian Period, some 500 million years ago when there was an explosion of new forms of animal life on Earth. The Sanctacaris is from an early group of arthropods that gave rise to sea urchins, horseshoe crabs, and spiders.



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Reconstruction by Marianne Collins.



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Celia Deane-Drummond is a professor of theology and biological sciences at University College Chester. Her distinguished contributions to the new discipline of "ecothology" reflect her early interest in botany and her later concentration on Christian theological studies. She also has written searchingly about the theological and ethical implications of new developments in genetics. Dr. Deane-Drummond did her first baccalaureate degree at Girton College, Cambridge, and took honors in natural sciences. She went on to earn a Ph.D. in plant physiology at Reading University in 1980 and to do post-doctoral research in botany, first at the University of British Columbia and then at Cambridge University. Upon changing fields, she received a post-graduate diploma in Christian studies from Canada's Regent College in 1983, a baccalaureate degree with honors in theology from Trinity College, Bristol in 1989, and a Ph.D. in theological studies from the University of Manchester in 1992. Dr. Deane-Drummond began her teaching career as a lecturer in botany at Durham University. She became involved with theological education through her curricular design work with the International Consultancy for Religion, Education and Culture from 1991 to 1994 at the same time she was also a visiting lecturer in theological studies at University of Manchester. She then joined the theology and religious studies faculty at Chester where she was promoted to professor in 2000 and named the director of the new Centre for Religion and the Biosciences, which was formally launched in 2002. The winner of several prizes for curricular development, including a John Templeton Foundation Science and Religion Course Program grant, Dr. Deane-Drummond has received additional research support from the St. Gabriel Trust and the Christendom Trust. She is an honorary fellow of St. Deiniol's Library, a member of the board of advisors of the Templeton Foundation, and chairperson of the Science and Religion Forum of Great Britain. She serves on the editorial board of the *British Journal of Theological Education* and is editor of *Ecotheology*, a journal promoting dialogue between scientists and theologians on ecological matters. As a consultant to the Roman Catholic Bishops' Conference of England and Wales, she has helped to shape Church policy on environmental issues. The author of more than fifty articles in scientific and scholarly journals and eight chapters in volumes of collected works, she is the editor of two books, both published in 2003,

Reordering Nature: Theology, Society and the New Genetics (with Bronislaw Szerszynski) and *Brave New World: Theology, Ethics and the Human Genome*. Dr. Deane-Drummond is also the author or co-author of ten other books, including *Creation Through Wisdom: Theology and the New Biology* (2000), *Biology and Theology Today: Exploring the Boundaries* (2001), and, most recently, *The Ethics of Nature*, which was published by Blackwell this year.



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Leverhulme Research Professor of Human Evolution at Cambridge University,

Robert A. Foley is director of the university's Leverhulme Centre for Human Evolutionary Studies, which he co-founded (with Marta Mirazon Lahr) in 2001, and a fellow of King's College, Cambridge. His research is concerned with understanding the pattern of human evolution in terms of evolutionary processes. He has focused on evolutionary ecology, social evolution, community ecology, and biogeography. In recent years, he has attempted to integrate genetic, archaeological, and fossil evidence into a coherent model of geographical diversification, adaptive change, and behavioral evolution in recent human populations. Dr. Foley has worked extensively in Africa, and he currently directs a major collaborative study on the population history of Island Melanesia. Educated at Ardingly College, Sussex, and at Cambridge, where he studied at Peterhouse and took his B.A. and a Ph.D. in anthropology in 1980, he began his teaching career as a lecturer in anthropology at the University of Durham. He returned to Cambridge in 1986 as a university lecturer in biological anthropology and was named a reader in evolutionary anthropology in 1998. He served as director of the Duckworth Laboratory for ten years. Dr. Foley was appointed director of the Leverhulme Centre in 1991 and to his current professorship earlier this year. He has been a visiting professor at the University of New Mexico and the University of Cape Town. A fellow and former vice president of the Royal Anthropological Institute (RAI) and a fellow of the Linnaean Society, he has held the Lister Lectureship at the British Association for the Advancement of Sciences, a Fulbright Visiting Scholarship, and a Royal Society Senior Research Fellowship. Dr. Foley has delivered named lectures at the RAI, the University of São Paulo, the University of Uppsala, and the University of Wales, Aberystwyth. The author of more than 100 papers on human evolution and prehistory published in academic journals, he has edited two books and served as co-editor of four others, including (with Peter Donnelly) *Genes, Fossils and Behaviour: An Integrated Approach to Human Evolution* (2001). He is also the author of four other books, *Off-Site Archaeology and Human Adaptation in Eastern Africa* (1981), *Another Unique Species: Patterns of Human Evolutionary Ecology* (1987), *Humans Before Humanity: An Evolutionary Perspective* (1995), and, most recently, (with Roger Lewin)

Principles of Human Evolution, which was published by Blackwell last year.

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Nigel R. Franks, a professor of animal behavior and ecology at the University of Bristol, is a leading expert on ants who has studied social insects for a quarter century. His pioneering research demonstrated that insights from the organization of ant colonies could form the basis for computer algorithms. His interest in mathematical biology and the application of social-organization theory led him to undertake investigations that showed how simple rules of thumb employed by individual social insects at a purely local level can generate complex adaptive features at the level of the whole society. Educated at the University of Leeds, where he took first-class honors in special studies zoology, Dr. Franks also earned his Ph.D. in zoology at Leeds, based on extensive fieldwork on army ants in Panama. His thesis was recognized as the best doctoral dissertation in zoology in the United Kingdom in 1980 by the Zoological Society of London, which presented him with its Thomas Henry Huxley Award. Dr. Franks studied with E.O. Wilson at Harvard University on a post-doctoral fellowship from the Royal Commission for the Exhibition of 1851. His research interests expanded during this period from ecology to animal behavior, and he conducted one of the first studies of behavioral conflicts within ant societies, which led to a co-authored (with Edward Scovell) cover article in *Nature*. Appointed a lecturer in ecology at the University of Bath in 1982, he was named a professor of animal behavior and ecology in 1996, a post he held until accepting his present position at Bristol in 2001. Dr. Franks has been a professional fellow at the Institute of Advanced Study in Berlin and held a Venture Research Fellowship awarded by British Petroleum. His investigations have been supported by the Royal Society, the Nuffield Foundation, NATO, the Leverhulme Trust, the Wellcome Trust, and the Linnaean Society, as well as by American and British corporations and United Kingdom research councils. He has delivered invited lectures in Finland, Sweden, Germany, and the United States and has frequently taken part in radio and television programs promoting public understanding of science, including a BBC film that received an award from the British Association for the Advancement of Science. Formerly a correspondent for *Trends in Ecology and Evolution*, Dr. Franks serves on the editorial board of the *Proceedings of the Royal Society of London* (Biological Sciences). He has published some 120 papers in scientific journals and is the

co-author of three books, including (with John H. Sudd) *The Behavioural Ecology of Ants* (1987), (with Andrew F. G. Bourke) *Social Evolution in Ants* (1995), and, most recently, (with Scott Carmazine, Jean-Louis Deneubourg, James Sneyd, Guy Theraulaz, and Eric Bonabeau), *Self Organization in Biological Systems*, which was published in 2001 by Princeton University Press.

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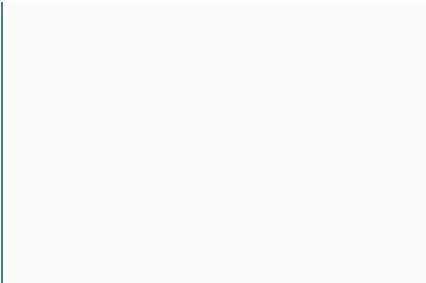
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A theologian well known for his teaching and writing in the area of science and religion, **John F. Haught** is the Thomas Healey Distinguished Professor at Georgetown University, where he has been a member of the theology faculty for the past thirty-five years. In a 1999 study, *God After Darwin: A Theology of Evolution*, he argued that while a purposeful universe would have to possess at least a loosely directional aim, purpose is "a much wider notion than design." Dr. Haught claims the debate between evolutionists and creationists is fundamentally misdirected because both these competing ideologies lack an adequate discussion of novelty, which he sees as a necessary component of evolution and a central theme in theological understanding of divine creativity. In his view, Darwin's vision of life, instead of being hostile to religion—as scientific skeptics and many believers have thought it to be—actually provides a fertile setting for mature reflection on ideas about God and cosmic meaning. Dr. Haught extends his discussion of evolutionary theism in his latest book, *Deeper Than Darwin: The Prospect for Religion in the Age of Evolution*, which was published last year by Westview Press. In the unfinished nature of the universe and its evolution into a "stupendous array of beauty," he finds support for his belief that the cosmos has some overall point and human beings a basis for hope. A graduate of St. Mary's University in Baltimore, Dr. Haught earned his Ph.D. in theology at The Catholic University of America in 1970. He formerly served as chair of the Georgetown theology department and is the founding director of its Center for the Study of Science and Religion. A recipient of the Owen Garrigan Award in Science and Religion given by Seton Hall University and of the Sophia Award of the Washington Theological Union, Dr. Haught is a member of the board of advisors of the John Templeton Foundation. He has published more than fifty articles and essays in collected volumes and is the editor of *Science and Religion in Quest of Cosmic Purpose* (2000). He is the author of eleven books, including *The Promise of Nature: Ecology and Cosmic Purpose* (1993) and *Science and Religion: From Conflict to Conservation* (1995), which has been translated into Romanian, Korean, Persian, and Chinese.



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Richard E. Lenski is an evolutionary biologist who watches evolution unfold in a laboratory. The Hannah Distinguished Professor of Microbial Ecology at Michigan State University, he is internationally acclaimed for research focusing on ecological processes and genetic mechanisms that cause evolutionary change. He studies microorganisms in order to take advantage of their rapid generations and large populations, which makes it feasible to test evolutionary hypotheses by direct experimentation, and has examined 20,000 generations of *E. coli* bacteria to trace their adaptation to specific environments. He also looks at the evolution of artificial life in the form of self-replicating computer programs that mutate at random, compete, and evolve to perform complex functions. A graduate of Oberlin College, where he was elected to Phi Beta Kappa, Dr. Lenski earned a Ph.D. in zoology at the University of North Carolina in 1982. After post-doctoral research in zoology at the University of Massachusetts, Amherst, and a semester as a visiting assistant professor of biological sciences at Dartmouth College, he joined the faculty of the University of California, Irvine, as an assistant professor of ecology and evolutionary biology in 1985 and was named an associate professor three years later. Dr. Lenski accepted his present chair at Michigan State in 1991. He has taught special courses and workshops at the University of California, Davis, at the University of Basel and the University of Fribourg in Switzerland, and at the University of Alaska. In 1995, he served as vice-chair of the Gordon Research Conference on "Population Biology and Evolution of Microbes and their Accessory Elements," and two years later he was co-chair of the National Research Conference on "Ecology and Evolution of Infectious Diseases." A member of Sigma Xi, the honorary scientific society, he has been the recipient of an American Society of Naturalists President's Award, a National Science Foundation Presidential Young Investigator Award, a Guggenheim Fellowship, and a John D. and Catherine T. MacArthur Foundation Fellowship. He is a former visiting fellow of All Souls College, Oxford, and a fellow of the American Academy of Microbiology, and the American Academy of Arts and Sciences. A former associate editor of both *Theoretical Population Biology and Evolution*, Dr. Lenski formerly served on the editorial boards of *Microbial Ecology* and of the *American Naturalist*, on the editorial advisory board of *Molecular Ecology*, and as area editor of the Oxford

University Press *Encyclopedia of Evolution*. He is the author or co-author of some 150 papers published in leading scientific journals.

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George R. McGhee, Jr. is a professor of geological sciences, ecology, and evolution at Rutgers University. His research involves the analysis of ancient ecosystems and the evolution of life within an ecological context. A recent focus has been the testing of various hypotheses of mass extinction. He also has investigated the evolution and adaptation of organic form in nature using the analytic techniques of theoretical morphology, which involves the computer simulation of both real and nonexistent biological form within geometric hyperspaces, as well as the analysis of why certain forms have been evolved by life whereas others—although geometrically possible—have not. A graduate of North Carolina State University, Dr. McGhee received a master's degree in geology from the University of North Carolina and a Ph.D. in geological sciences from the University of Rochester in 1978. He joined the Rutgers faculty that year and was named to his present position in 1993. He has been a visiting scientist at the Field Museum of Natural History in Chicago, a guest lecturer and a guest professor at the University of Tübingen, a research associate at the Museum of Natural History in New York, and a guest participant at the Santa Fe Institute and the Konrad Lorenz Institute of Evolution and Cognitive Research in Altenberg, Austria. Dr. McGhee served as the United States chair of the eight-year International Geological Correlation Program 216 on "Global Biological Events in Earth History." A former associate editor and adjunct editor of *Paleobiology*, he is the author or co-author of some 120 papers published in scientific journals and the author of two books, *The Late Devonian Mass Extinction* (1996), which was selected by *Choice* as the outstanding academic book in the year of its publication, and *Theoretical Morphology: The Concept and Its Application*, which was published by Columbia University Press in 1999.



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The Liberty Hyde Bailey Professor of Plant Biology at Cornell University, **Karl J. Niklas** is a leading scholar in plant biomechanics and allometry. His research involves the application of engineering principles to the understanding of plant form and function and their adaptive evolution. Through the quantitative evaluation of plant anatomy, morphology, and development as they relate to various biological functions necessary for plant growth, he has shown that much of plant evolution is understandable in the context of optimization processes involving trade-offs among equally important biological functions that have conflicting requirements. Dr. Niklas is a graduate of The City College of New York, where he was elected to Phi Beta Kappa. He studied at the University of Illinois as a Woodrow Wilson Fellow and received a Ph.D. in paleobotany in 1974. As a Fulbright-Hays Fellow, he did post-doctoral work at Berkbeck College, London. He was a curator at the New York Botanical Garden for four years before joining the Cornell faculty in 1978 as an assistant professor of botany. Named a professor in 1985, he was appointed to his present chair in 2000. Dr. Niklas was made an Erskine Fellow of the University of Canterbury in Christchurch, New Zealand earlier this year. He is a former fellow of the New York Academy of Sciences, a fellow of the Linnaean Society of London, and an honorary member of Gamma Sigma Delta, the agriculture honor society. A past recipient of a Guggenheim Fellowship, he has also received the George Gaylord Simpson Prize given by Yale University's Peabody Museum, the Michael A. Cichan Award of the Botanical Society of America, the SUNY Chancellor's Award for Excellence in Teaching, the Botanical Society of America's Lifetime Achievement Award, the Alexander von Humboldt Forschungspreis for Senior Distinguished USA Scientists, and the Jeanette Siron Pelton Award. He delivered the first Japanese *Annals of Botany* Lecture in 1999 and has given numerous other invited lectures throughout the United States, Canada, Europe, and New Zealand. The current editor-in-chief of the *American Journal of Botany*, Dr. Niklas has been an associate editor of *Evolution*, *Paleobiology*, and *Organic Geochemistry*, and a member of the editorial board of the *Journal of Arboriculture*. He is the author some 200 papers published in scientific journals, twenty-five chapters in volumes of collected works, and three books, including *Plant Biomechanics: An Engineering Approach to*

Plant Form and Function (1992), *Plant Allometry: The Scaling of Form and Process* (1994), and, most recently, *The Evolutionary Biology of Plants*, which was published by the University of Chicago Press in 1997.

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THE
HUMBLE
APPROACH
INITIATIVE



PURPOSE IN EVOLUTION: Is Convergence Sufficiently Ubiquitous to Give a Directional Sign?

A symposium sponsored by the John Templeton Foundation

24, 25, and 26 June 2004

Vatican Observatory. Castel Gandolfo, Italy



PARTICIPANTS

Nicola S. Clayton
Celia Deane-Drummond
Robert A. Foley
Nigel R. Franks
John F. Haught
Richard E. Lenski
George R. McGhee, Jr.
Karl J. Niklas
Michael Ruse
Anthony J. Trewavas
Hal Whitehead
Gregory Allan Wray

Michael Ruse, the Lucyle T. Werkmeister Professor of Philosophy at Florida State University, is a philosopher of science who has found in evolution a kind of *Weltanschauung*, a world picture that gives meaning to life. He believes that we know what we know because of biology and remains a skeptic on the existence of an ultimate reality as attractive as he finds the possibility. A native of England, he attended a Quaker school before entering the University of Bristol, where he studied philosophy and mathematics. Immigrating to North America, he took a master's degree in philosophy at McMaster University in Ontario, Canada, and then returned to Bristol where he earned a Ph.D. in philosophy in 1970. Already on the faculty of Ontario's University of Guelph, he became a full professor of philosophy of science and of zoology there in 1974, a position he held until accepting his present chair at Florida State in 2000. Dr. Ruse has been a visiting professor at Indiana University, a visiting scholar at Harvard University's Museum of Comparative Zoology, and, at Cambridge University, an associate at Clare Hall, a visiting scholar at Pembroke College, an associate and a fellow of Wolfson College, and a member of the university's department of the history and philosophy of science. He also has served as invited director of the École Pratique des Hautes Études in Montpellier, France. A former Erskine Fellow at the University of Canterbury in Christchurch, New Zealand, he also has held Guggenheim and Killam fellowships and currently holds a Templeton Foundation research grant for exploring the constructive interaction of science and religion. He has honorary degrees from the University of Bergen in Norway and McMaster University, and is a fellow of both the Royal Society of Canada and the American Association for the Advancement of Science (AAAS). In 2001, he delivered the Gifford Lectures at the University of Glasgow. The founding editor of *Biology and Philosophy*, he serves on the editorial boards of eight other journals as well as serving as general editor of *Cambridge Studies in Philosophy and Biology*. He is a former president of the History and Philosophy of Science Section of the AAAS and presently an associate of the Center for Science and Religion at the Lutheran School of Theology in Chicago. A prolific author, Dr. Ruse has written twenty-four books, edited nine, contributed to sixty others, and published more than a hundred scholarly articles. His comprehensive study of the history of the relationship between

scientific ideas about evolution and cultural notions of progress, *Monad to Man: The Concept of Progress in Evolutionary Biology* (1996), was widely hailed as demonstrating how a pervasive Enlightenment optimism regarding the possibility of ongoing social and moral improvement influenced the speculative theorizing of early biologists. In *Mystery of Mysteries: Is Evolution a Social Construction?* (1999), Dr. Ruse considered the careers and theories of past and contemporary scientists as he probed the extent to which science is both an objective reality with special standards of truth finding and a sequence of paradigms that subjectively mirror our ever-shifting views of the world. The most recent book in his trilogy on evolution, *Darwin and Design: Does Evolution Have a Purpose?*, published by Harvard University Press in 2003, explores the relation between evolutionary theory and the classical argument from design for the existence of God. He is currently completing a manuscript entitled *Darwinism and its Discontents* for Cambridge University Press.



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Professor of plant biochemistry at the University of Edinburgh, **Anthony J. Trewavas** investigates the role of calcium in the movement of signals from outside to inside cells during plant development. From his studies of how plants in the wild manipulate the signals they perceive, he has concluded that plants act in ways that optimize their chances of surviving and reproducing—behavior he defines as intelligence. Dr. Trewavas devised a test of phenotypic plasticity by inserting a gene, which produces a calcium-sensitive protein, from luminous jellyfish into a plant, which then responded to environmental stimuli with flashes of light. His subsequent research into how plants learn led him to the conclusion that plant intelligence is a factor in the evolutionary process that has been overlooked because orthodox science assumes intelligence requires mobility. Dr. Trewavas was educated at University College, London, where he earned his baccalaureate degree and, in 1964, was awarded a Ph.D. in biochemistry. After six years as a post-doctoral fellow at the University of East Anglia, he joined the Edinburgh faculty as a lecturer. He was named to his present position in 1990. Dr. Trewavas was the inaugural visiting professor at the Michigan State University Plant Research Laboratory in 1973 and has been a visiting lecturer at the National Academy of Sciences in Poland, the University of Illinois, the University of Alberta, the University of California, Davis, the University of Bonn, the University of North Carolina, the National University of Mexico, the University of Athens, the University of Milan, and the University of Santiago in Chile. A fellow of the Royal Society, the Royal Society of Edinburgh, the Royal Society of Arts, the World Innovation Foundation, and the Centre for Future Studies, he is a member of Academia Europea and a life member of the American Society of Plant Physiologists. He has served as an advisor to NASA, the Australian Senior Fellowships Committee, the Australian Research Council, the United States/Israel Binational Science Committee, the Israel Science Foundation, the Swiss National Science Council, the United States Development Agency, the National Institutes of Health, and the National Science Foundation. Formerly a member of the editorial boards of *Plant Physiology* and *Botanica Acta*, he currently serves on the editorial boards of *Plant*, *Cell and Environment* and *Trends in Plant Science*, as well as on the advisory editorial board of the *Biochemical Journal*. Dr. Trewavas is the author or co-

author of more than 200 articles published in scientific journals and essays in volumes of collected works. He is the editor (with D. H. Jennings) of *Plasticity in Plants* (1986) and the author of *Molecular and Cellular Aspects of Calcium in Plant Development*, which was published in 1985 by Plenum Press.



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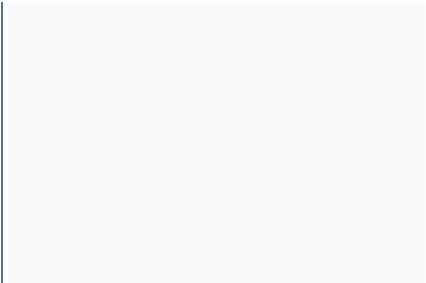
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Hal Whitehead, Killam Professor of Biology at Dalhousie University in Halifax, Nova Scotia, cruises the oceans for weeks at a time to collect data for his studies of sperm and northern bottlenose whales. His research focuses on their behavior, principally social organization and the transmission of culture among these cetaceans, as well as on their ecology and population biology. He tracks them by listening to their sounds in habitats from the Indian Ocean to the North Atlantic to the South Pacific, including the equatorial waters near the Galápagos Islands, the archipelago off the coast of Ecuador visited by Charles Darwin. Dr. Whitehead has developed sophisticated analytical tools for studying whales that are used by marine biologists around the world. Educated at the Uppingham School and at Christ's College, Cambridge, he studied pure mathematics and received a diploma in mathematical statistics before switching to zoology and earning a Ph.D. at Cambridge in 1981. He spent three years as a post-doctoral research fellow and then as a research associate at the Newfoundland Institute for Cold Ocean Science at Memorial University of Newfoundland before joining the faculty as adjunct assistant professor. Accepting an Izzak Walton Killam research fellowship, he moved on to Dalhousie University where he became a NSERC (National Sciences and Engineering Research Council of Canada) University Research Fellow and an assistant research professor in 1986. Named a professor of biology in 1996, he assumed his present chair in 2000. Dr. Whitehead is the recipient of a COSEWIC (Committee on the Status of Endangered Wildlife in Canada) Service Award and has won prizes for his science articles for the general public and for children. He has been a Hefner Lecturer at Miami University in Oxford, Ohio and a Super Speaker at the Duke University Marine Laboratory in Beaufort, North Carolina. The author of some 120 papers published in scientific journals and fifteen essays in collected volumes, he is the co-editor (with Janet Mann, Richard C. Connor, and Peter L. Tyack) of *Cetacean Societies: Field Studies of Whales and Dolphins* (2000) and the author of *Voyage to the Whales* (1989) and, most recently, *Sperm Whales: Social Evolution in the Ocean*, which was published last year by the University of Chicago Press.



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An associate professor of biology at Duke University, **Gregory Allan Wray** investigates the evolution of developmental gene networks and mechanisms of transcriptional regulation. His research projects utilize a variety of approaches and organisms to study the role that ordinary growth processes play in the evolution of genotype-phenotype relationships. Dr. Wray is a graduate of William and Mary College and earned his Ph.D. in zoology from Duke in 1987. After post-doctoral fellowships at Indiana University's Institute of Molecular and Cell Biology and at the Friday Harbor Laboratories at the University of Washington, he joined the faculty of Vanderbilt University as an assistant professor of biology in 1992. The next year he accepted a position as an assistant professor of ecology and evolution at the State University of New York, Stony Brook, where he became a member of the Graduate Program in Molecular and Cell Biology and was promoted to associate professor in 1997. He was named to his current position at Duke two years later. A visiting faculty member at the Friday Harbor Laboratories on several occasions, Dr. Wray is the recipient of an Alfred P. Sloan Foundation Young Investigator Award in Molecular Evolution. In addition, he has received research support from the National Science Foundation, the National Aeronautics and Space Administration, NATO, the Stowers Institute for Medical Research, and the National Institutes of Health. A co-organizer of conferences on issues in developmental biology in Edinburgh in 1994 and in Woods Hole, Massachusetts in 1999, he is organizing a Gordon Conference on "Evolutionary, Ecological, and Functional Genomics" to be held in New London, Connecticut in 2007. He was formerly an associate editor of the *Journal of Experimental Zoology*, the *American Naturalist*, the *American Zoologist*, and *Invertebrate Biology*. He currently serves as an associate editor of *Evolution & Development*, a journal he co-founded in 1999, *Development, Genes, and Evolution*, and *The Quarterly Review of Biology*. Dr. Wray is the author or co-author of some seventy papers published in scientific journals and essays in volumes of collected works.

