University of Pennsylvania
ScholarlyCommons

Boardman Lectureship in Christian Ethics | Department of Religious Studies

4-24-1997

Creation and the Theory of Evolution

Francisco J. Ayala
University of California, Irvine

Wolfhart Pannenberg
University of Munich

Follow this and additional works at: http://repository.upenn.edu/boardman

 Part of the Ecology and Evolutionary Biology Commons

Recommended Citation
Ayala, Francisco J. and Pannenberg, Wolfhart, "Creation and the Theory of Evolution" (1997). *Boardman Lectureship in Christian Ethics*. 6.
http://repository.upenn.edu/boardman/6

Boardman Lecture XXXV. Edited and Foreword by Susan Marks.

This paper is posted at ScholarlyCommons. http://repository.upenn.edu/boardman/6
For more information, please contact libraryrepository@pobox.upenn.edu.

Creation and the Theory of Evolution

Abstract
The Boardman Lecture, in cooperation with the Center For Theology and The Natural Sciences and The John Templeton Foundation, funded a conference on Creation and Theory of Evolution. The conference explored religion and science by offering two different approaches to the question of human origins. Geneticist Francisco Ayala explains the present state of our understanding of evolution and argues that such human phenomena as morality and religion are by-products of the evolutionary process that cannot be explained by natural selection. His lecture appears as "The Evolutionary Transcendence of Humankind." Dr. Pannenberg stressed that the God of religious faith must be the Creator of the same nature that is studied by scientists. He explores aspects of the Genesis creation story that are compatible with the theory of evolution. His lecture is "Human Life: Creation *Versus* Evolution?"

Disciplines
Ecology and Evolutionary Biology

Comments
Boardman Lecture XXXV. Edited and Foreword by Susan Marks.

This presentation is available at ScholarlyCommons: http://repository.upenn.edu/boardman/6

The Boardman Lectureship in Christian Ethics
(Founded 1899)
in cooperation with the
Center For Theology And The Natural Sciences
and The John Templeton Foundation

XXXV

CREATION AND THE THEORY OF EVOLUTION

Delivered Before
The University of Pennsylvania
April 24, 1997

The Evolutionary Transcendence of Humankind
by
DR. FRANCISCO J. AYALA

Human Life: Creation *Versus* Evolution?
by
DR. WOLFHART PANNENBERG

Edited by
Susan Marks

Philadelphia
Published for the Department of Religious Studies
University of Pennsylvania

Copyright 1998 for the authors by the Department of Religious Studies, University of Pennsylvania

Table of Contents

Forward v

The Boardman Lectures in Christian Studies vii

Faculty, Department of Religious Studies. xi

The Boardman Lectureship in Christian Ethics:
The Foundation xiii

The Boardman Lectureship in Christian Ethics:
The Original Outline Written by Dr. George Dana Boardman
and Mrs. Ella Covell Boardman in 1899. xv

THE EVOLUTIONARY TRANSCENDENCE OF HUMANKIND
Dr. Francisco J. Ayala 1

Notes 18

HUMAN LIFE: CREATION *VERSUS* EVOLUTION?
Dr. Wolfhart Pannenberg 21

Forward

The thirty-fifth Dana Boardman Lecture on Christian Ethics at the University of Pennsylvania was coordinated with funds provided by The John Templeton Foundation and the University Lecture Series of the Center for Theology and the Natural Sciences (Berkeley) so that a short conference on Creation and Theory of Evolution could be presented. The object was to enrich explorations of religion and science by offering two significant and different approaches to the question of human origins.

Noted geneticist Francisco Ayala of the University of California (Irvine) explained the present state of our understanding of evolution and argued that such human phenomena as morality and religion are by-products of the evolutionary process that cannot be explained by natural selection. His lecture, after some revisions by the author, appears in this publication as "The Evolutionary Transcendence of Humankind".

The Boardman Lecturer, Dr. Wolfhart Pannenberg, a well known theologian and Emeritus Professor at the University of Munich, developed a theological argument. Dr. Pannenberg stressed that the God of religious faith must be the Creator of the same nature that is studied by scientists. To illustrate one application of this claim, he explored aspects of the Genesis creation story that are compatible with the theory of evolution. His lecture "Human Life: Creation *Versus* Evolution?" challenges us to see that *"Versus"* need not describe the relationship of Creation and Evolution.

Both Dr. Ayala and Dr. Pannenberg have written extensively on questions of science, philosophy and religion.

I would like to thank Professor Stephen Dunning, who organized the conference, for his assistance in preparing this publication.

Susan Marks
University of Pennsylvania

The Boardman Lectures in Christian Ethics

I. The Golden Rule
George Dana Boardman, 1900

II. Modern Study of Conscience
Oliver Huckel, 1906

III. The Ethical Teachings of Jesus
Lyman Abbott, 1909

IV. Ethics of the Larger Neighborhood
Hamilton Wright Mabie, 1914

V. World Peace and the College Man
David Starr Jordan, 1915

VI. Jesus on Love to God; Jesus on Love to Man
James Moffatt, 1922

VII. The Social Teaching of Jesus Christ
The Social Principles of the Teaching of Jesus
The Social Consequences of the Teaching of Jesus
Francis Greenwood Peabody, 1924

VIII. The Fundamentals of Christianity
Charles Foster Kent, 1925

CHRISTIAN ETHICS, 1927

IX. *Christian Ethics in Everyday Life*
Frederick R. Griffin

X. *Ethics in Education*
Edwin C. Broome

XI. *The Christian Home*
William P. McNally

XII. *The Originality of Christian Ethics*
George C. Foley

XIII. *The Two Roads*
Boyd Edwards

VIV. The Religious Motive in Philosophy
Henry Bradford Washburn, 1931

XV. Creative Christian Living: A Christian Ethic For The College Student
Walter Brooke Stabler, 1934

XVI. Without Compromises
Walter Brooke Stabler, 1934

XVII. My Father's Business: A Practical Study of Business Ethics
Walter Brooke Stabler, 1935

XVIII. The Valley of Decision
Edward G. Harris, 1956

XIX. Mission to Mankind
Edward G. Harris, 1957

XX. God and Our Daily Work
Edward G. Harris, 1958

XXI. Ethics in Ferment
Edward G. Harris, 1959

XXII. Doubt and Faith
Edward G. Harris, 1960

XXIII. The Urgency of Ethics
Edward G. Harris, 1961

XXIV. Religion and Politics in America: The Prospects for Civility
Harvey Cox, 1984

XXV. God's Unilateralism: Towards a Theology of Peace
Dorothee Solle, 1985

XXVI. Public Theology, Civil Religion, and American Catholicism
David J. O'Brien, 1986

XXVII. The Impossible Dream
Walter E. Fauntroy, 1988

XXVIII. 'A' for Ethics: An Alphabet of Action
Absolutely Not: Do It My Way Or Die!
Bible: Big Brother or ...?
Consequences: Is AIDS the Judgement of God?
Death: Does God Zap Us Here or Hereafter?
John W. Bowker, 1988

XXIX. Homelessness: A Challenge to the Gospel Message
Mary Scullion, 1990

XXX. Christian Feminist Theology in Global Context
Rosemary Radford Ruether, 1991

XXXI. Two Christian Ideals for Business
Michael Novak, 1993

XXXII. The Culture of Disbelief
Stephen L. Carter, 1994

XXXIII. Some Skeptical Thoughts About Active Euthanasia and Assisted Suicide
William F. May, 1994

XXXIV. Religion and Diplomacy
Robert Runcie, 1995

XXXV. *Creation and the Theory of Evolution*
The Evolutionary Transcendence of Humankind
Franciso J. Ayala, 1997
Human Life: Creation Versus *Evolution*
Wolfhart Pannenberg, 1997

FACULTY 1997-8

Department of Religious Studies
University of Pennsylvania

Stephen N. Dunning, Ph.D., Harvard, Chair and Associate Professor, Modern Western Religious Thought and Methodology

Robert A. Kraft, Ph.D., Harvard, Professor, Hellenistic Religions: Judaism and Christianity

William LaFleur, Ph.D., Chicago, Professor, Japanese Religion

E. Ann Matter, Ph.D., Yale, Professor, History of Christianity, Medievel Thought, Women and Religion

James O'Donnell, Ph.D., Yale, Professor, Classical and Late Antique Worlds, Medieval Latin Christianity

David Ruderman, Ph.D., Hebrew University, Professor, Modern Jewish Intellectual History

Barbara R. von Schlegell, Ph.D., U.C. Berkeley, Assistant Professor, Islamic Religion

David Stern, Ph.D., Harvard, Professor, Classical Judaism, Midrashic Studies, Comparative Literatures

Guy R. Welbon, Ph.D., Chicago, Associate Professor, Religions of Southern Asia, Hinduism and Buddhism, General History of Religions

THE BOARDMAN LECTURESHIP IN CHRISTIAN ETHICS: *THE FOUNDATION*

On June 6, 1899, the Trustees of the University of Pennsylvania accepted from the Reverend George Dana Boardman, D.D., LL.D., and Mrs. Ella Covell Boardman, his wife, a Deed of Gift, providing for a foundation to be known as "The Boardman Lectureship in Christian Ethics", the income of the fund to be expended solely for the purposes of the Trust. Dr. Boardman served the University for twenty-three years as Trustee, for a time as Chaplain, and often as Ethical Lecturer. After providing for refunding out of the said income, any depreciation which might occur in the capital sum, the remainder is to be expected in procuring the delivery in each year at the University of Pennsylvania, one or more lectures on Christian Ethics from the standpoint of the life, example and teachings of the Lord Jesus Christ, and in the publication in book form, of the said lecture or lectures within four months of the completion of their delivery. The volume in which they are printed shall always have its forefront a printed statement of the history, outline, and terms of the Foundation.

On July 6, 1899, a Standing Committee on "The Boardman Lectureship in Christian Ethics" was constituted, to which shall be committed the nominations of the lecturers and the publications of the lectures in accordance with the Trust.

On February 6, 1900, on the recommendation of this committee, the Reverend George Dana Boardman, D.D., LL.D., was appointed Lecturer on Christian Ethics on the Boardman Foundation for the current year.

The Boardman Lectureship in Christian Ethics:
The Original Outline Written by Dr. George Dana Boardman and Mrs. Ella Covell Boardman in 1899

I. THE PURPOSE

First, the purpose is not to trace the history of the various ethical theories; this already done in our own noble University. Nor is it the purpose to teach theology, whether natural, Biblical, or ecclesiastical. But the purpose of this Lectureship is to teach Christian Ethics; that is to say, the practical application of the precepts and behavior of JESUS CHRIST to everyday life.

And this is the greatest of the sciences. It is a great thing to know astronomy; for it is the science of mighty orbs, stupendous distances, majestic adjustments in time and space. It is a great thing to know biology; for it is the science of living organisms - the starting, growth, health, movements, life itself. It is a great thing to know law; for it is the science of legislation, government, equity, civilization. It is a great thing to know philosophy; for it is the science of men and things. It is a great thing to know theology; for it is the science of God. But what avails it to know everything in space from atom to star, everything in time from protoplasm to Deity, if we do not know how to manage ourselves amid the complex, delicate ever-varying duties of daily life? What will it profit a man if he gain the whole world - the world geographical, commercial, political, intellectual, and after all lose his own soul? What can a University give in exchange for a Christlike character? Thus it is that ethics is the science of sciences. Very significant is the motto of our own noble University - "Literae Sine Moribus Vanae".

And Jesus of Nazareth is the supreme ethical authority. When we come to receive from Him our final awards, he will not ask, "What was your theory of atoms? What did you think about evolution? What was your doctrine of atonement? What was your mode of baptism?" But he will ask,"What did you do with Me? Did you accept Me as your personal standard of character? Were you a practical everyday Christian?" Christian Ethics will be the judgement test.

In sum, the purpose of this Lectureship in Christian Ethics is to build up human character after the model of Jesus Christ.

II. RANGE OF THE LECTURESHIP

Secondly, the Range of the Lectureship. This range should be as wide as human society itself. The following is offered in way of general outline and suggestive hints, each hint being of course but a specific or technical illustration growing out of some vaster underlying Principle.

1. Man's Heart-Nature. - And, first, man's religious nature. For example: Christian (not merely ethical) precepts concerning man's capacity for religion; worship; communion; divineness; immortality; duty of religious observances; the Beatitudes; in brief, Manliness in Christ.

2. Man's Mind-Nature. - Secondly, man's intellect-nature. For example: Christian precepts concerning reason; imagination; invention; aesthetics; language, whether spoken, written, sung, builded, painted chiseled, acted, etc.

3. Man's Society-Nature. - Thirdly, man's society-nature. For example:

   (a) Christian precepts concerning the personal life: for instance: conscientiousness, honesty, truthfulness, charity, chastity, courage, independence, chivalry, patience, altruism, etc.

   (b) Christian precepts concerning family life; for instance: marriage, divorce; duties of husbands, wives, parents, children, kindred, servants, place of woman, etc.

   (c) Christian precepts concerning the business life; for instance: rights of labor; rights of capital; right of pecuniary independence; living within means; life insurance; keeping morally accurate accounts; endorsing; borrowing; prompt liquidation; sacredness of trust funds, personal and corporate; individual moral responsibility of directors and officers; trust-combinations; strikes; boycotting; limits of speculation; profiting by ambiguities; single tax; nationalization of property, etc.

(d) Christian precepts concerning the civic life; for instance: responsibilities of citizenship; elective franchise; obligations of office; class-legislation; legal oaths; custom-house conscience; sumptuary laws; public institutions, whether educational, ameliorative, or reformatory; function of money; standard of money; public credit; civic reforms; caucuses, etc.

(e) Christian precepts concerning international life; for instance: treaties; diplomacy; war; arbitration; disarmament; tariff; reciprocity; mankind, etc.

(f) Christian precepts concerning ecclesiastical life: for instance: sectarianism, comity in mission fields; co-operation; unification of Christendom, etc.

(g) Christian precepts concerning the academic life; for instance: literary and scientific ideals, professional standards of morality; function of the press; copyrights; obligations of scholarship, etc.

In sum, Christian precepts concerning the tremendous problems of sociology, present and future.

Not that all the lectures must agree at every point; often there are genuine cases of conscience, or reasonable doubt, in which a good deal can be justly said on both sides. The supreme point is this: Whatever the topic may be, the lecturer must discuss it conscientiously, in light of Christ's own teachings and character; and so awaken the consciences of his listeners, making their moral sense more acute.

4. Man's Body-Nature. - Fourthly, man's body-nature. For example: Christian precepts concerning environment; heredity, health, cleanliness, temperance; self-control; athletics; public hygiene; tenement-houses; prophylactics; the five senses; treatment of animals, etc.

In sum, the range of topics for this Lectureship in Christian Ethics should include whatever tends to society-building, or perfection of personal character in Christ. Surely, here is material enough, and this without any need of duplication, for centuries to come.

III. SPIRIT OF THE LECTURESHIP

Thirdly, the Spirit of this Lectureship. Every lecture must be presented from the standpoint of Jesus Christ. It must be distinctly understood and the founder of the Lectureship cannot emphasize the point too strongly, that every lecture in these successive courses must be unambiguously Christian; that is, from the viewpoint of the Divine Son of Mary. This Lectureship must be something more than a lectureship in moral philosophy, or in a church theology; it must be a lectureship in Christian morality, or practical ethics from the standpoint of Christ's own personal character, example, and teachings.

IV. QUALIFICATIONS OF THE LECTURER

Fourthly, the Qualification of the Lecturer. The founder hopes that the lecturer may often be, perhaps generally, a layman; for instance: a merchant, a banker, a lawyer, a statesman, a physician, a scientist, a professor, an artist, a craftsman, for Christian ethics is a matter of daily practical life rather than of metaphysical theology. The founder cares not what the ecclesiastical connection of the lecturer may be: whether Baptist or an Episcopalian, a Quaker or a Latinist; for Christian ethics as Christ's behavior is not a matter of ecclesiastical ordination or of sect. The only pivotal condition of the Lectureship in this particular is this: The lecturer himself must be unconditionally loyal to our only King, our Lord Jesus Christ; for Jesus Christ Himself is the world's true, everlasting Ethics.

CREATION AND THE THEORY OF EVOLUTION

THE EVOLUTIONARY TRANSCENDENCE OF HUMANKIND

Francisco J. Ayala
Department of Ecology and Evolutionary Biology
University of California, Irvine

❖ SETTING THE STAGE

It does not take a great deal of biological expertise to realize that humans have organs and limbs similar to those of other animals; that we bear our young like other mammals; that, bone by bone, there is a precise correspondence between the skeletons of a chimpanzee and a human. It also does not take much reflection to notice the distinct uniqueness of our species. There is the bipedal gait and the enlarged brain. Much more conspicuous than the anatomical differences are the distinct behaviors and their outcomes. Humans have elaborate social and political institutions, codes of law, literature and art, ethics and religion; humans build roads and cities, travel by motorcars, ships and airplanes, and communicate by means of telephones, computers and televisions.

I will first, in the pages that follow, set forth the biological continuity between humans and animals. I outline what we currently know about the evolutionary history of humans for the last four million years, from bipedal but small-brained Australopithecus to modern Homo sapiens, our species, through the prolific tool-maker Homo habilis and the continent-wanderer Homo erectus. The genes of living humans manifest that our ancestors were no fewer than several thousand individuals at any one time in the history of these hominid species.

I shall, then, identify anatomical traits that distinguish us from other animals, and point out our two kinds of heredity, the biological and the cultural. Biological inheritance is based on the transmission of genetic information, in humans very much the same as in other sexually reproducing organisms. But cultural inheritance is distinctively human, based on transmission of information by a teaching and learning process, which is, in principle, independent of biological parentage. Cultural inheritance makes possible the cumulative transmission of experience from generation to generation. Cultural heredity is a swifter and more effective (because it can be designed) mode of adaptation to the environment than the biological mode. The advent of cultural heredity ushered in cultural evolution, which transcends biological evolution.

In the latter part of this lecture, I explore ethical behavior as a model case of a distinctive human trait, and seek to ascertain the causal connections between human ethics and human biology. My conclusions are that (1) the proclivity to make ethical judgments, i.e., to evaluate actions as

either good or evil, is rooted in our (biological) nature, a necessary outcome of our exalted intelligence; but (2) the moral codes which guide our decisions as to which actions are good and which ones are evil, are products of culture, including social and religious traditions. This second conclusion contradicts those evolutionists and sociobiologists who claim that the morally good is simply that which is promoted by the process of biological evolution.

❖ Human Origins

Mankind is a biological species that has evolved from other species that were not human. In order to understand human nature, we must know our biological make-up and whence we come, the story of our humbler beginnings. For a century after the publication of Darwin's On the Origin of Species in 1859, the story of evolution was reconstructed with evidence from paleontology (the study of fossils), biogeography (the study of the geographical distribution of organisms), and from the comparative study of living organisms: their morphology, development, physiology, and the like. Since mid-twentieth century we have, in addition, molecular biology, the most informative and precise discipline for reconstructing the ancestral relationships of living species.

Our closest biological relatives are the great apes and, among them, the chimpanzees, who are more related to us than they are to the gorillas, and much more than to the orangutans. The hominid lineage diverged from the chimpanzee lineage 5-7 million years ago (Mya) and it evolved exclusively on the African continent until the emergence of *Homo erectus*, somewhat before 1.8 Mya. The first known hominid, *Ardipithecus ramidus*, lived 4.4 Mya, but it is not certain that it was bipedal or in the direct line of descent to modern humans, *Homo sapiens*. The recently described *Australopithecus anamensis*, dated 3.9-4.2 Mya, was bipedal and has been placed in the line of descent to *Australopithecus afarensis*, *Homo habilis*, *H. erectus*, and *H. sapiens*. Other hominids, not in the direct line of descent to modern humans, are *Australopithecus africanus*, *Paranthropus aethiopicus*, *P. boisei*, and *P. robustus*, who lived in Africa at various times between 3 and 1 Mya, a period when three or four hominid species lived contemporaneously in the African continent.

Shortly after its emergence in tropical or subtropical eastern Africa, *H. erectus* spread to other continents. Fossil remains of *H. erectus* are known from Africa, Indonesia (Java), China, the Middle East, and Europe. *H. erectus* fossils from Java have been dated 1.81+0.04 and 1.66+0.04 Mya, and from Georgia between 1.6 and 1.8 Mya. Anatomically distinctive *H. erectus* fossils have been found in Spain, deposited before 780,000 years ago, the oldest in southern Europe.

The transition from *H. erectus* to *H. sapiens* occurred around 400,000 years ago, although this date is not well determined owing to uncertainty as to whether some fossils are *erectus* or "archaic" forms of *sapiens*.

H. erectus persisted for some time in Asia, until 250,000 years ago in China and perhaps until 100,000 ago in Java, and thus was coetaneous with early members of its descendant species, *H. sapiens.* Fossil remains of Neandertal hominids (*Homo neanderthalensis)* appeared in Europe around 200,000 years ago and persisted until thirty or forty thousand years ago. The Neandertals had, like *H. sapiens*, large brains. A few years ago, they were thought to be ancestral to anatomically modern humans, but now we know that modern humans appeared at least 100,000 years ago, much before the disappearance of the Neandertals. Moreover, in caves in the Middle East, fossils of modern humans have been found dated 120,000-100,000 years ago, as well as Neandertals dated at 60,000 and 70,000 years ago, followed again by modern humans dated at 40,000 years ago. It is unclear whether the two forms repeatedly replaced one another by migration from other regions, or whether they coexisted in some areas. Recent genetic evidence indicates that interbreeding between *sapiens* and *neanderthalensis* never occurred.

There is considerable controversy about the origin of modern humans. Some anthropologists argue that the transition from *H. erectus* to archaic *H. sapiens* and later to anatomically modern humans occurred consonantly in various parts of the Old World. Proponents of this "multiregional model" emphasize fossil evidence showing regional continuity in the transition from *H. erectus* to archaic and then modern *H. sapiens.* In order to account for the transition from one to another species (something which cannot happen independently in several places), they postulate that genetic exchange occurred from time to time between populations, so that the species evolved as a single gene pool, even though geographic differentiation occurred and persisted, just as geographically differentiated populations exist in other animal species, as well as in living humans. This explanation depends on the occurrence of persistent migrations and interbreeding between populations from different continents, of which no direct evidence exists. Moreover, it is difficult to reconcile the multiregional model with the contemporary existence of different species or forms in different regions, such as the persistence of *H. erectus* in China and Java for more than one hundred thousand years after the emergence of *H. sapiens.* Other scientists argue instead that modern humans first arose in Africa or in the Middle East somewhat prior to 100,000 years ago, and from there spread throughout the world, replacing the preexisting populations of *H. erectus* or archaic *H. sapiens.*

❖ How Many Humans

Some proponents of this "African replacement" model claim further that the transition from archaic to modern *H. sapiens* was associated with a very narrow bottleneck, consisting of only two or very few individuals who are the ancestors of all modern mankind. This particular claim of a narrow bottleneck is supported, erroneously as I will soon show, by the

investigation of a peculiar small fraction of our genetic inheritance, the mitochondrial DNA (mtDNA). The African (or Middle East) origin of modern humans is, however, supported by a wealth of recent genetic evidence and is, therefore, favored by many evolutionists.

The genetic information we inherit from our parents is encoded in the linear sequence of the DNA's four nucleotide components (represented by A, C, G, T) in the same fashion as semantic information is encoded in the sequence of letters of a written text. Most of the DNA is contained in the chromosomes inside the cell nucleus. The total amount of DNA in a human cell nucleus consists of six thousand million nucleotides, half in each set of 23 chromosomes inherited from each parent. A relatively small amount of DNA, about 16,000 nucleotides, exists in the mitochondria, cell organelles outside the nucleus. The mtDNA is inherited in a peculiar manner, that is, exclusively along the maternal line. The inheritance of the mtDNA is a gender mirror image of the inheritance of the family name. Sons and daughters inherit their mtDNA from their mother but only the daughters transmit it to their progeny, just as sons and daughters receive the family name of the father, but only the sons transmit it to their children.

Analysis of the mtDNA from ethnically diverse individuals has shown that the mtDNA sequences of modern humans coalesce to one ancestral sequence, the "mitochondrial Eve" that existed in Africa about 200,000 years ago[1]. This Eve, however, is not the one mother from whom all humans descend, but an mtDNA molecule (or the woman carrier of that molecule) from whom all modern mtDNA *molecules* descend.

Some science writers have drawn the inference that all humans descend from only one, or very few women, but this is based on a confusion between gene genealogies and individual genealogies. Gene genealogies gradually coalesce towards a unique DNA ancestral sequence (in a similar fashion as living species, such as humans, chimpanzees, and gorillas, coalesce into one ancestral species). Individual genealogies, on the contrary, increase by a factor of two in each ancestral generation: an individual has two parents, four grandparents, and so on[2]. Coalescence of a gene genealogy into one ancestral gene, originally present in one individual, does not disallow the contemporary existence of many other individuals, who are also our ancestors, and from whom we have inherited the other genes.

This conclusion can be illustrated with an analogy. My family name is shared by many people, who live in Spain, Mexico, the Philippines, and other countries. An historian of our family name has concluded that all Ayalas descend from Don Lope Sánchez de Ayala, grandson of Don Vela, vassal of King Alfonso VI, who established the domain ("señorío") de Ayala in the year 1085, in the now Spanish Basque province of Alava. Don Lope is the Adam from whom we all descend on the paternal line, but we also descend from many other men and women who lived in the

eleventh century, as well as earlier and later.

The inference warranted by the mtDNA analysis is that the mitochondrial Eve is the ancestor of modern humans in the maternal line. Any person has a single ancestor in the *maternal line* in any given generation. Thus a person inherits the mtDNA from the mother, from the maternal grandmother, from the great grandmother on the maternal line, and so on. But the person also inherits other genes from other ancestors. The mtDNA that we have inherited from the mitochondrial Eve represents one-four-hundred-thousandth of the DNA present in any modern human (sixteen thousand out of six billion nucleotides). The rest of the DNA, 400,000 times more than the mtDNA, we have inherited from other contemporaries of the mitochondrial Eve.

From how many contemporaries? The issue of how many human ancestors we had in the past has been elucidated by investigating the genes of the human immune system[3]. The genes of the human leukocyte antigen (HLA) complex exist in multiple versions, which provide people with the diversity necessary to confront bacteria and other pathogens that invade the body. The evolutionary history of some of these genes shows that they coalesce into ancestral genes 30-60 Mya, that is, much before the divergence of humans and apes. (Indeed, humans and apes share many of these genes.) The mathematical theory of gene coalescence makes it possible to estimate the number of ancestors that must have lived in any one generation in order to account for the preservation of so many diverse genes through hundreds of thousands of generations. The estimated *effective* number is about 100,000 individuals per generation. This "effective" number of individuals is an average rather than a constant number, but it is a peculiar kind of average (a "harmonic mean"), compatible with much larger but not much smaller numbers of individuals in different generations. Thus, through millions of years our ancestors existed in populations that were 100,000 individuals strong, or larger. Population bottlenecks may have occurred on rare occasions. But the genetic evidence indicates that human populations never consisted of fewer than several thousand individuals.

❖ From Biology to Culture

The most distinctive human anatomical traits are erect posture and large brain. We are the only vertebrate species with a bipedal gait and erect posture; birds are bipedal, but their backbone stands horizontal rather than vertical. Brain size is generally proportional to body size; relative to body mass, humans have the largest (and most complex) brain. The chimpanzee's brain weighs less than a pound; a gorilla's slightly more. The human male adult brain is 1400 cubic centimeters (cc) about three pounds in weight.

Evolutionists used to raise the question whether bipedal gait or large brain came first, or whether they evolved consonantly. The issue is now

resolved. Our *Australopithecus* ancestors had, since four million years ago, a bipedal gait, but a small brain, about 450 cc, a pound in weight. Brain size starts to increase notably with our *Homo habilis* ancestors, about 2.5 Mya, who had a brain about 650 cc and also were prolific tool-makers (hence the name *habilis*). Between one and two million years afterwards, there lived *Homo erectus*, with adult brains up to 1200 cc. Our species, *Homo sapiens*, has a brain about three times as large as that of *Australopithecus*, 1300-1400 cc, or some three pounds of gray matter. Our brain is not only much larger than that of chimpanzees or gorillas, but also much more complex. The cerebral cortex, where the higher cognitive functions are processed, is in humans disproportionally greater than the rest of the brain when compared to apes.

Erect posture and large brain are not the only anatomical traits that distinguish us from nonhuman primates, even if they may be the most obvious. A list of our most distinctive anatomical features includes the following (of which the last five items are not detectable in fossils):

- Erect posture and bipedal gait (entail changes of the backbone, hipbone, and feet)
- Opposing thumbs and arm and hand changes (make possible precise manipulation)
- Large brain
- Reduction of jaws and remodeling of face
- Changes in skin and skin glands
- Reduction in body hair
- Cryptic ovulation (and extended female sexual receptivity)
- Slow development
- Modification of vocal tract and larynx
- Reorganization of the brain

Humans are notably different from other animals not only in anatomy, but also and no less importantly in their behavior, both individually and socially. A list of distinctive human behavioral traits includes the following:

- Subtle expression of emotions
- Intelligence: abstract thinking, categorizing, and reasoning
- Symbolic (creative) language
- Self-awareness and death-awareness
- Tool-making and technology
- Science, literature, and art
- Ethics and religion
- Social organization and cooperation (division of labor)
- Legal codes and political institutions

Humans live in groups that are socially organized, and so do other primates. But primate societies do not approach the complexity of

human social organization. A distinctive human social trait is culture, which may be understood as the set of non-strictly biological human activities and creations. Culture includes social and political institutions, ways of doing things, religious and ethical traditions, language, common sense and scientific knowledge, art and literature, technology, and in general all the creations of the human mind. The advent of culture has brought with it cultural evolution, a superorganic mode of evolution superimposed on the organic mode, and which has in the last few millennia become the dominant mode of human evolution. Cultural evolution has come about because of cultural change and inheritance, a distinctively human mode of achieving adaptations to the environment and transmitting the adaptations through the generations.

Humans have two kinds of heredity—biological and cultural, which may also be called organic and superorganic, or *endosomatic* and *exosomatic* systems of heredity. Biological inheritance in humans is very much like that in any other sexually reproducing organism; it is based on the transmission of genetic information encoded in DNA from one generation to the next by means of the sex cells. Cultural inheritance, on the other hand, is based on transmission of information by a teaching-learning process, which is in principle independent of biological parentage. Culture is transmitted by instruction and learning, by example and imitation, through books, newspapers and radio, television and motion pictures, through works of art, and by any other means of communication. Culture is acquired by every person from parents, relatives and neighbors, and from the whole human environment.

Cultural inheritance makes possible for humans what no other organism can accomplish—the cumulative transmission of experience from generation to generation. Animals can learn from experience, but they do not transmit their experiences, their "discoveries," to the following generations (at least not to any large extent). Animals have individual memory, but they do not have a "social memory." Humans, on the other hand, have developed a culture because they can transmit cumulatively their experiences from generation to generation.

Cultural inheritance makes possible cultural evolution, that is, the evolution of knowledge, social structures, ethics, and all other components that make up human culture. Cultural inheritance makes possible a new mode of adaptation to the environment that is not available to nonhuman organisms—adaptation by means of culture. Organisms in general adapt to the environment by means of natural selection, by changing their genetic constitution over generations to suit the demands of the environment. But humans, and humans alone, can also adapt by changing the environment to suit the needs of their genes. (Animals build nests and modify their environment also in other ways, but the manipulation of the environment by any nonhuman species is trivial compared to that by humans.) For the last few millennia humans have

been adapting the environment to their genes more often than their genes to the environment.

In order to extend its geographical habitat, or to survive in a changing environment, a population of organisms must become adapted, through slow accumulation of genetic variants sorted out by natural selection, to the new climatic conditions, different sources of food, different competitors, and so on. The discovery of fire and the use of shelter and clothing allowed humans to spread from the warm tropical and subtropical regions of the Old World to the whole earth, except for the frozen wastes of Antarctica, without the anatomical development of fur or hair. Humans did not wait for genetic mutants promoting wing development; they have conquered the air in a somewhat more efficient and versatile way by building flying machines. People travel the rivers and the seas without gills or fins. The exploration of outer space has started without waiting for mutations providing humans with the ability to breathe with low oxygen pressures or to function in the absence of gravity; astronauts carry their own oxygen and specially equipped pressure suits. From their obscure beginnings in Africa, humans have become the most widespread and abundant species of mammal on earth. It was the appearance of culture as a superorganic form of adaptation that made humans the most successful animal species.

Cultural adaptation has prevailed in mankind over biological adaptation because it is a more rapid mode of adaptation and because it can be directed. A favorable genetic mutation newly arisen in an individual can be transmitted to a sizeable part of the human species only through innumerable generations. However, a new scientific discovery or technical achievement can be transmitted to all humans, potentially at least, in less than one generation. Moreover, whenever a need arises, culture can directly pursue the appropriate changes to meet the challenge. On the contrary, biological adaptation depends on the accidental availability of a favorable mutation, or of a combination of several mutations, at the time and place where the need arises.

Erect posture and large brain are distinctive anatomical features of modern humans. High intelligence, symbolic language, religion, and ethics are some of the behavioral traits that distinguish us from other animals. The account of human origins that I have sketched implies a continuity in the evolutionary process that goes from our nonhuman ancestors of eight million years ago through primitive hominids to modern humans. A scientific explanation of that evolutionary sequence must account for the emergence of human anatomical and behavioral traits in terms of natural selection together with other distinctive biological causes and processes. One explanatory strategy is to focus on a particular human feature and seek to identify the conditions under which this feature may have been favored by natural selection. Such a strategy may lead

to erroneous conclusions as a consequence of the fallacy of selective attention: some traits may have come about not because they are themselves adaptive, but rather because they are associated with traits that are favored by natural selection.

Geneticists have long recognized the phenomenon of "pleiotropy," the expression of a gene in different organs or anatomical traits. It follows that a gene that becomes changed owing to its effects on a certain trait will result in the modification of other traits as well. The changes of these other traits are epigenetic consequences of the changes directly promoted by natural selection. The cascade of consequences may be, particularly in the case of humans, very long and far from obvious in some cases. Literature, art, science, and technology are among the behavioral features that may have come about not because they were adaptively favored in human evolution, but because they are expressions of the high intellectual abilities present in modern humans: what may have been favored by natural selection (its "target") was an increase in intellectual ability rather than of those particular activities as such.

❖ Whence Ethics and Values?

I now will briefly explore ethics and ethical behavior as a model case of how we may seek the evolutionary explanation of a distinctively human trait. I select ethical behavior because morality is a human trait that seems remote from biological processes. My goal is to ascertain whether an account can be advanced of ethical behavior as an outcome of biological evolution and, if such is the case, whether ethical behavior was directly promoted by natural selection, or has rather come about as an epigenetic manifestation of some other trait that was the target of natural selection.

I will argue that ethical behavior (the proclivity to judge human actions as either good or evil) has evolved as a consequence of natural selection, not because it was adaptive in itself, but rather as a pleiotropic consequence of the high intelligence characteristic of humans. However, I will first point out that the question whether ethical behavior is biologically determined may refer either to (1) the capacity for ethics (i.e., the proclivity to judge human actions as either right or wrong) and which I will refer to as "ethical behavior," or (2) the moral *norms* or moral codes accepted by human beings for guiding their actions. My theses are that: (1) the capacity for ethics is a necessary attribute of human nature, and thus a product of biological evolution; but (2) moral norms are products of cultural evolution, not of biological evolution.

My first thesis is grounded on the argument that humans exhibit ethical behavior because their biological makeup determines the presence of the three necessary, and jointly sufficient, conditions for ethical behavior: the ability to anticipate the consequences of one's own actions, the ability to make value judgments, and the ability to choose between alternative courses of action. I thus maintain that ethical behavior came about in

evolution not because it is adaptive in itself, but as a necessary consequence of humanity's eminent intellectual abilities, which are an attribute directly promoted by natural selection.

My second thesis contradicts the proposal of many distinguished evolutionists who, since Darwin's time, have argued that the norms of morality are derived from biological evolution. It also contradicts the sociobiologists who have recently developed a subtle version of that proposal. The sociobiologists' argument is that human ethical norms are sociocultural correlates of behaviors fostered by biological evolution. I argue that such proposals are misguided and do not escape the naturalistic fallacy. It is true that both natural selection and moral norms sometimes coincide on the same behavior; i.e., the two are consistent. But this isomorphism between the behaviors promoted by natural selection and those sanctioned by moral norms exists only with respect to the consequences of the behaviors; the underlying causations are completely disparate.

I shall now develop these ideas.

❖ Ethical Judgments *versus* Ethical Norms

I have noted that the question of whether ethical behavior is biologically determined may refer to either one of the following issues: (1) Is the capacity for ethics—the proclivity to judge human actions as either right or wrong—determined by the biological nature of human beings? (2) Are the systems or codes of ethical norms accepted by human beings biologically determined? A similar distinction can be made with respect to language. The issue whether the capacity for symbolic language is determined by our biological nature is different from the question of whether the particular language we speak (English, Spanish, or Japanese) is biologically necessary.

The first question posed is more fundamental; it asks whether or not the biological nature of *Homo sapiens* is such that humans are necessarily inclined to make moral judgments and to accept ethical values, to identify certain actions as either right or wrong. Affirmative answers to this first question do not necessarily determine what the answer to the second question should be. Independently of whether or not humans are necessarily ethical, it remains to be determined whether particular moral prescriptions are in fact determined by our biological nature, or whether they are chosen by society, or by individuals. Even if we were to conclude that people cannot avoid having moral standards of conduct, it might be that the choice of the particular standards used for judgment would be arbitrary, or that it depended on some other, nonbiological criteria. The need for having moral values does not necessarily tell us what these moral values should be, just as the capacity for language does not determine which language we will speak.

The thesis I propose is that humans are ethical beings by their biological nature. Humans evaluate their behavior as either right or

wrong, moral or immoral, as a consequence of their eminent intellectual capacities which include self-awareness and abstract thinking. These intellectual capacities are products of the evolutionary process, but they are distinctively human. Thus, I maintain that ethical behavior is not causally related to the social behavior of animals, including sin and reciprocal "altruism."

A second thesis that I put forward is that the moral norms according to which we evaluate particular actions as morally either good or bad (as well as the grounds that may be used to justify the moral norms) are products of cultural evolution, not of biological evolution. The norms of morality belong, in this respect, to the same category of phenomena as the languages spoken by different peoples, their political and religious institutions, and the arts, sciences, and technology. The moral codes, like these other products of human culture, are often consistent with the biological predispositions of the human species, dispositions we may to some extent share with other animals. But this consistency between ethical norms and biological tendencies is not necessary or universal; it does not apply to all ethical norms in a given society, much less in all human societies.

Moral codes, like any other dimensions of cultural systems, depend on the existence of human biological nature and must be consistent with it in the sense that they could not counteract it without promoting their own demise. Moreover, the acceptance and persistence of moral norms is facilitated whenever they are consistent with biologically conditioned human behaviors. But the moral norms are independent of such behaviors in the sense that some norms may not favor, and may hinder, the survival and reproduction of the individual and its genes, which are the targets of biological evolution. Discrepancies between accepted moral rules and biological survival are, however, necessarily limited in scope or would otherwise lead to the extinction of the groups accepting such discrepant rules.

❖ The Capacity for Moral Reasoning

I argue that the question whether ethical behavior is determined by our biological nature must be answered in the affirmative. By "ethical behavior" I mean here to refer to the urge toward *judging* human actions as either good or bad, which is not the same as "good behavior" (i.e., *doing* what is perceived as good instead of what is perceived as evil). Humans exhibit ethical behavior by nature because their biological constitution determines the presence in them of the three necessary, and jointly sufficient, conditions for ethical behavior. These conditions are: (a) the ability to anticipate the consequences of one's own actions; (b) the ability to make value judgments; and (c) the ability to choose between alternative courses of action. I shall briefly examine each of these abilities and show that they exist as a consequence of the eminent intellectual capacity of human beings.

The ability to anticipate the consequences of one's own actions is the

most fundamental of the three conditions required for ethical behavior. Only if I can anticipate that pulling the trigger will shoot the bullet, which in turn will strike and kill my enemy, can the action of pulling the trigger be evaluated as nefarious. Pulling a trigger is not in itself a moral action; it becomes so by virtue of its relevant consequences. My action has an ethical dimension only if I do anticipate these consequences.

The ability to anticipate the consequences of one's actions is closely related to the ability to establish the connection between means and ends; that is, of seeing a mean precisely as mean, as something that serves a particular end or purpose. This ability to establish the connection between means and their ends requires the ability to anticipate the future and to form mental images of realities not present or not yet in existence.

The ability to establish the connection between means and ends happens to be the fundamental intellectual capacity that has made possible the development of human culture and technology. The evolutionary roots of this capacity may be found in the evolution of bipedal gait, which transformed the anterior limbs of our ancestors from organs of locomotion into organs of manipulation. The hands thereby gradually became organs adept for the construction and use of objects for hunting and other activities that improved survival and reproduction, that is, that increased the reproductive fitness of their carriers.

The construction of tools, however, depends not only on manual dexterity, but in perceiving them precisely as tools, as objects that help to perform certain actions, that is, as means that serve certain ends or purposes: a knife for cutting, an arrow for hunting, an animal skin for protecting the body from the cold. The hypothesis I am propounding is that natural selection promoted the intellectual capacity of our biped ancestors, because increased intelligence facilitated the perception of tools as tools, and therefore their construction and use, with the ensuing amelioration of biological survival and reproduction.

The development of the intellectual abilities of our ancestors took place over two million years or longer, gradually increasing the ability to connect means with their ends and, hence, the possibility of making ever more complex tools serving remote purposes. The ability to anticipate the future, essential for ethical behavior, is therefore closely associated with the development of the ability to construct tools, an ability that has produced the advanced technologies of modern societies and that is largely responsible for the success of mankind as a biological species.

The second condition for the existence of ethical behavior is the ability to make value judgments, to perceive certain objects or deeds as more desirable than others. Only if I can see the death of my enemy as preferable to his or her survival (or vice versa) can the action leading to his or her demise be thought of as moral. If the alternative consequences of an action are neutral with respect to value, the action cannot be characterized as ethical. The ability to make value judgments depends on the capacity for abstraction, that is, on the capacity to perceive actions or

objects as members of general classes. This makes it possible to compare objects or actions with one another and to perceive some as more desirable than others. The capacity for abstraction, necessary to perceiving individual objects or actions as members of general classes, requires an advanced intelligence such as exists in humans and apparently in them alone. Thus, I see the ability to make value judgments primarily as an implicit consequence of the enhanced intelligence favored by natural selection in human evolution. Nevertheless, valuing certain objects or actions and choosing them over their alternatives can be of biological consequence; doing this in terms of general categories can be beneficial in practice.

Moral judgments are a particular class of value judgments; namely those where preference is not dictated by one's own interest or profit, but by regard for others, which may cause benefits to particular individuals (altruism), or take into consideration the interests of a social group to which one belongs. Value judgments indicate preference for what is perceived as good and rejection of what is perceived as bad; good and bad may refer to monetary, aesthetic, or all sorts of other kinds of values. Moral judgments concern the values of right and wrong in human conduct.

The third condition necessary for ethical behavior is the ability to choose between alternative courses of action. Pulling the trigger can be a moral action only if I have the option not to pull it. A necessary action beyond our control is not a moral action: the circulation of the blood or the digestion of food are not moral actions.

Whether there is free will has been much discussed by philosophers, and this is not the appropriate place to review the arguments. I will only advance two considerations based on our common-sense experience. One is our profound personal conviction that the possibility of choosing between alternatives is genuine rather than only apparent[4]. The second consideration is that when we confront a given situation that requires action on our part, we are able mentally to explore alternative courses of action, thereby extending the field within which we can exercise our free will. In any case, if there were no free will, there would be no ethical behavior; morality would only be an illusion. The point that I wish to make here is, however, that free will is dependent on the existence of a well-developed intelligence, which makes it possible to explore alternative courses of action and to choose one or another in view of the anticipated consequences.

In summary, my proposal is that ethical behavior is an attribute of the biological make-up of humans and is, in that sense, a product of biological evolution. But I see no evidence that ethical behavior developed because it was adaptive in itself. I find it hard to see how *evaluating* certain actions as either good or evil (as opposed to just choosing some actions rather than others, or evaluating them with respect to their practical consequences)

would promote the reproductive fitness of the evaluators. Nor do I see how there might be some form of "incipient" ethical behavior that would then be further promoted by natural selection. The three necessary conditions for there being ethical behavior are manifestations of advanced intellectual abilities.

It rather seems that the likely target of natural selection may have been the development of these advanced intellectual capacities. This development was favored by natural selection because the construction and use of tools improved the strategic position of our biped ancestors. Once bipedalism evolved and tool-using and tool-making became possible, those individuals more effective in these functions had a greater probability of biological success. The biological advantage provided by the design and use of tools persisted long enough so that intellectual abilities continued to increase, eventually yielding the eminent development of intelligence that is characteristic of *Homo sapiens.*

❖ The Content of Moral Norms

There are many theories concerned with the rational grounds for morality, such as deductive theories that seek to discover the axioms or fundamental principles that determine what is morally correct on the basis of direct moral intuition. There also are theories, like logical positivism or existentialism, which negate rational foundations for morality, reducing moral principles to emotional decisions or to other irrational grounds. Since the publication of Darwin's theory of evolution by natural selection, philosophers as well as biologists have attempted to find in the evolutionary process the justification for moral norms. The common ground to all such proposals is that evolution is a natural process that achieves goals that are desirable and thereby morally good; indeed it has produced humans. Proponents of these ideas claim that only the evolutionary goals can give moral value to human action: whether a human deed is morally right depends on whether it directly or indirectly promotes the evolutionary process and its natural objectives.

Herbert Spencer[5] was perhaps the first philosopher seeking to find the grounds of morality in biological evolution. More recent attempts include those of the distinguished evolutionists J.S. Huxley[6] and C.H. Waddington[7], and of Edward O. Wilson[8], [9], founder of sociobiology as an independent discipline engaged in discovering the biological foundations of social behavior. I have argued elsewhere[10] that the moral theories proposed by Spencer, Huxley, and Waddington are mistaken and fail to avoid the naturalistic fallacy[11]. These authors argue, in one or another fashion, that the standard by which human actions are judged good or evil derives from the contribution the actions make to evolutionary progress. A blunder of this argumentation is that it is based on value judgments about what is or is not progressive in (particularly human) evolution[12]. There is nothing objective in the evolutionary process itself

that makes the success of bacteria, which have persisted for more than three billion years and in enormous diversity and numbers, less "progressive" than that of the vertebrates, even though the latter are more complex[13]. Nor are the insects, of which more than one million species exist, less successful or less progressive from a purely biological perspective than humans or any other mammal species. Moreover, the proponents of evolution-grounded moral codes fail to demonstrate why the promotion of biological evolution by itself should be the standard to measure what is morally good.

The most recent and most subtle attempt to ground the moral codes on the evolutionary process emanates from the sociobiologists, particularly from E.O. Wilson[8], [9], who starts by proposing that "scientists and humanists should consider together the possibility that the time has come for ethics to be removed temporarily from the hands of the philosophers and biologicized."[14] The sociobiologists argue that our perception that morality exists is an epigenetic manifestation of our genes, which so manipulate humans as to make them believe that some behaviors are morally "good" so that people behave in ways that are good for their genes. Humans might not otherwise pursue these behaviors (altruism, for example) because their genetic benefit is not apparent (except to sociobiologists after the development of their discipline)[15].

As I have argued elsewhere, the sociobiologists' account of the evolution of the moral sense is misguided[10], [16]. As I have shown above, we make moral judgments as a consequence of our eminent intellectual abilities, not as an innate way for achieving biological gain. Moreover, the sociobiologists' position may be interpreted as calling for the supposition that those *norms* of morality should be considered supreme that achieve the most biological (genetic) gain (because that is, in their view, why the moral sense evolved at all). This, in turn, would justify social preferences, including racism and even genocide, that many of us (sociobiologists included) judge morally obtuse and even heinous.

The evaluation of moral codes or human actions must take into account biological knowledge, but biology is insufficient for determining which moral codes are, or should be, accepted. This may be reiterated by returning to the analogy with human languages. Our biological nature determines the sounds that we can or cannot utter and also constrains human language in other ways. But a language's syntax and vocabulary are not determined by our biological nature (otherwise, there could not be a multitude of tongues), but are products of human culture. Likewise, moral norms are not determined by biological processes, but by cultural traditions and principles that are products of human history.

❖ Concluding Remarks: Science and Its Limits

Science is a wondrously successful way of knowing. Science seeks explanations of the natural world by formulating hypotheses that are

subject to the possibility of empirical falsification or corroboration. A scientific hypothesis is tested by ascertaining whether or not predictions about the world of experience derived as logical consequences from the hypothesis agree with what is actually observed[16]. Science is a mode of inquiry into the nature of the universe that has been successful and of great consequence. Witness the proliferation of science academic departments in universities and other research institutions, the enormous budgets that the body politic and the private sector willingly commit to scientific research, and its economic impact. The Office of Management and the Budget (OMB) of the U.S. government has estimated that fifty percent of all economic growth in the United States since the Second World War can directly be attributed to scientific knowledge and technological advances. The technology derived from scientific knowledge pervades our lives: the high-rise buildings of our cities, thruways and long span-bridges, rockets that take us to the moon, telephones that provide instant communication across continents, computers that perform complex calculations in millionths of a second, vaccines and drugs that keep bacterial parasites at bay, gene therapies that replace DNA in defective cells. All these remarkable achievements bear witness to the validity of the scientific knowledge from which they originated.

Scientific knowledge is also remarkable in the way it emerges by way of consensus and agreement among scientists, and in the way new knowledge builds upon past accomplishment rather than starting anew with each generation or each new practitioner. Surely scientists disagree with each other on many matters; but these are issues not yet settled, and the points of disagreement generally do not bring into question previous knowledge. Modern scientists do not challenge that atoms exist, or that there is a universe with a myriad stars, or that heredity is encased in the DNA.

Science is a way of knowing, but it is not the only way. Knowledge also derives from other sources, such as common sense, artistic and religious experience, and philosophical reflection. The validity of the knowledge acquired by non-scientific modes of inquiry can be simply established by pointing out that science dawned in the sixteenth century, but mankind had for centuries built cities and roads, brought forth political institutions and sophisticated codes of law, advanced profound philosophies and value systems, and created magnificent plastic art, as well as music and literature. We thus learn about ourselves and about the world in which we live and we also benefit from products of this non-scientific knowledge. The crops we harvest and the animals we husband emerged millennia before the dawn of science from practices set down by farmers in the Middle East, Andean Sierras, and Mayan plateaus.

It is not my intention in this essay's final section to belabor the extraordinary fruits of nonscientific modes of inquiry. I wish simply to state something that is obvious, but becomes at times clouded by hubris, an infirmity of mores that all too often afflicts members of my profession. Successful as it is, and universally encompassing as its subject is, a scientific view of the world is hopelessly incomplete. There are matters of value and meaning that are outside the scope of science. Even when we achieve scientific understanding of a natural object or process, we are still missing matters that may well be thought by many to be of equal or greater import. Scientific knowledge may enrich aesthetic and moral perceptions, and may illuminate the significance of life and the world, but these are matters outside the realm of science.

On April 28, 1937, early in the Spanish Civil War, Nazi airplanes bombed the small Basque town of Guernica, the first time that a civilian population had been determinedly destroyed from the air. The Spanish painter Pablo Picasso had recently been commissioned by the Spanish Republican Government to paint a large composition for the Spanish pavilion at the Paris World Exhibition of 1937. In a frenzy of manic energy, the enraged Picasso sketched in two days and fully outlined in ten more days his famous *Guernica,* an immense painting of 25 feet, 8 inches by 11 feet, 6 inches. Suppose that I now would describe the images represented in the painting, their size and position, as well as the pigments used and the quality of the canvas. This description would be of interest, but it would hardly be satisfying if I had completely omitted aesthetic analysis and considerations of meaning, the dramatic message of the inhumanity conveyed by the outstretched figure of the mother pulling her slaughtered baby, the bellowing faces, the wounded horse or the satanic image of the bull.

Let *Guernica* be a metaphor of the point I wish to make. Scientific knowledge, like the description of size, materials, and geometry of *Guernica,* is satisfying and useful. But once science has had its say, there remains unsettled much about reality that is of interest, questions of value and meaning that are forever beyond the scope of science. In order to understand ourselves and our place in the economy of things, we need much more than scientific knowledge. We need psychology and sociology, as well as history, aesthetics and philosophy; if we seek religious understanding, we'll profit from theology.

My purpose in this essay has been to provide what I see as a necessary dimension, the biological one, of any view of human nature that seeks to be relevant and complete. But I do not pretend that biology provides now, or ever will provide, a complete understanding of what we humans are and our place in the universe[18].

Notes

1. E.O. Wilson and R.L. Cann, "The Recent African Genesis of Humans," *Scientific American*, April 1992, pp. 68-73.

2. The theoretical number of ancestors for any one individual becomes enormous after some tens of generations, but "inbreeding" occurs: after some generations, ancestors appear more than once in the genealogy.

3. F.J. Ayala, "The Myth of Eve: Molecular Biology and Human Origins," *Science* 270:1930-1936 (1995).

4. Confucius put it thus: "One may rob an army of its commander-in-chief; one cannot deprive the humblest man of his free will." *The Analects of Confucius*, translation and notes by Simon Leys, New York: Norton (1996).

5. H. Spencer, *The Principles of Ethics*. London (1893).

6. T.H. Huxley and J.S. Huxley, *Touchstone for Ethics*. New York: Harper (1947); J.S. Huxley, *Evolution in Action*. New York: Harper (1953).

7. C.H. Waddington, *The Ethical Animal*. London: Allen & Unwin (1960).

8. E.O. Wilson, *Sociobiology: the New Synthesis*. Cambridge, MA: Harvard University Press (1975).

9. E.O. Wilson, *On Human Nature*. Cambridge, MA: Harvard University Press (1978).

10. F.J. Ayala, "The biological roots of morality," *Biology and Philosophy* 2:235-252 (1987).

11. The "naturalistic fallacy" consists in identifying what "is" with what "ought" to be (G.E. Moore, *Principia Ethica*, Cambridge University Press, 1903). This error was already pointed out by Hume: "In every system of morality which I have hitherto met with I have always remarked that the author proceeds for some time in the

ordinary way of reasoning ... when of a sudden I am surprised to find, that instead of the usual copulations of propositions, *is* and *is not*, I meet with no proposition that is not connected with an *ought* or *ought not*. This change is imperceptible; but is, however, of the last consequence. For as this *ought* or *ought not* expresses some new relation or affirmation, it is necessary that it should be observed and explained; and at the same time a reason should be given, for what seems altogether inconceivable, how this new relation can be a deduction from others, which are entirely different from it." (D. Hume, *Treatise of Human Nature*. Oxford: Oxford University Press [1740], 1978.)

12. F.J. Ayala, "The evolutionary concept of progress." In: G.A. Almond *et al.*, eds., *Progress and Its Discontents*. Berkeley: University of California Press, pp. 106-124 (1982).

13. See S.J. Gould, *Full House. The Spread of Excellence from Plato to Darwin*. New York, NY: Harmony Books (1996).

14. E.O. Wilson, *Sociobiology: the New Synthesis*. Cambridge, MA: Harvard University Press, p. 562 (1975).

15. M. Ruse, *Taking Darwin Seriously: A Naturalistic Approach to Philosophy*. Oxford: Basil Blackwell (1986a); M. Ruse, "Evolutionary ethics: A phoenix arisen," *Zygon* 21:95-112 (1986b); M. Ruse and E.O. Wilson, "Moral Philosophy as Applied Science," *Philosophy: Journal of the Royal Institute of Philosophy* 61:173-192 (1986).

16. F.J. Ayala, "The Difference of Being Human: Ethical Behavior as an Evolutionary Byproduct." In: H. Rolston, III, ed., *Biology, Ethics and the Origin of Life*. Boston and London: Jones and Bartlett, pp. 113-135 (1995).

17. F.J. Ayala, "On the Scientific Method, Its Practice and Pitfalls." *History and Philosophy of Life Science* 16:205-240 (1994).

18. The text of this lecture incorporates substantial portions of my "Human Nature: One Evolutionist's View" (to appear in *Portraits of Human Nature*, N. Murphy and W.S. Brown, eds., Fortress Press, Minneapolis) and "So Human an Animal" (to appear in *Science & Theology: The New Consonance*, T. Peters, ed., Westview Press)

HUMAN LIFE: CREATION *VERSUS* EVOLUTION?

Wolfhart Pannenberg
Professor of Systematic Theology
University of Munich

❖ Ever since its first publication by Charles Darwin in 1859, the doctrine of evolution of living forms and species by natural selection among individual variations within a given population in a struggle for survival, has been a matter of dispute among scientists and of ideological controversy. The dispute among scientists, however, did not center on the issue of whether there is or can be a process of evolution of higher organized species from lower forms of life. Rather, the scientific discussions were mainly concerned with the question of whether the principle of natural selection is sufficient to explain the process of the emergence of ever new and more complex forms of life. There are a number of difficult questions related to this issue. First of all, what is the standard requirement according to which selection operates? Is adaptation to external conditions the standard of fitness for natural selection, as the mechanistic interpretation of Darwinism in the late 19th century assumed, or does the spontaneous productivity of genetic variation lead to the discovery of new natural "niches" for survival and consequently of new objects for adaptation? Furthermore, can a continuous and cumulative occurrence of small variants under the pressures of natural selection issue in the emergence of a new species, or do small changes tend to disappear because they don't fit in the overall system of the organism and of its functioning? Would, then, a "fulguration"[a lightning flash] of a complete new scheme of organization be required for a new species to emerge? Finally, how is the apparent direction of the evolutionary process towards ever more complex forms of organic life to be accounted for? These are but a few of the more important riddles that have plagued Darwinism from the start and still continue to vex its defenders. Nevertheless, the general perspective of the Darwinian theory has been victorious, though it is still hypothetical and the evidence for it rests on a somewhat defective fossil record rather than on experiential demonstration, since new species are not easy to create by experiment. For all its difficulties, the theory of evolution still provides the most plausible interpretation of what is known about the history of organic life on this planet.

Resistance to this new theory from the side of the churches had been predictable, since it stood in clear contrast, if not contradiction to the traditional concept of creation. For many centuries it had been taken for granted that, according to the Biblical account in the first chapter of Genesis, the species of plants and animals had been created by God on the fifth and the sixth day of creation and remained unchanged ever since. It is the position that so-called "creationists" defend to the present day. Even among those who did not cling to Biblical literalism, however, it seemed

unacceptable that the theory of evolution replaced God's purposive action in bringing about the different forms of life by a mechanical process of nature. In this controversy, the point is that before Darwin the purposive action of the creator had been understood to provide the only explanation for the fact of different species of animal life. Therefore, the proposal of a natural explanation for the same result was taken as a denial of God's purposive action in the creation of living forms. In principle, of course, the assumption of God's purposive action need not have excluded the use of natural causes in the execution of the Divine purpose. In fact, however, after Darwin's book *On the Origin of Species* had been published, Divine purpose and the mechanical operation of natural causes were taken as mutually exclusive.

Given the antagonistic climate of the early discussions on Darwin's theory, it is astonishing that from the beginning some leading British churchmen and theologians tried to reinterpret Christian doctrine in light of the perspective of evolution. The most remarkable of these attempts was a book edited by Charles Gore in 1889 under the title *Lux Mundi: A Series of Studies in the Religion of the Incarnation.* As the title suggests, the book reinterpreted the Incarnation of the Divine Logos in Jesus Christ in terms of providing the culmination of the evolution of life. While the process of natural evolution culminates in the emergence of the human race, so the history of the human race reached its climax in the incarnation. To a certain extent, such a theological scheme was suggested by early Church Fathers like Irenaeus. But now the picture of a salvific history of humanity leading toward the event of the incarnation was immensely broadened by including the process of natural evolution of life as prehistory of that salvific history. Interestingly, the authors contributing to *Lux Mundi* did not take the Darwinian evolution to describe a mechanical process, but rather a historical process. That was hardly warranted by the evolutionary theory prevalent around 1890. *Lux Mundi* rather pointed beyond that theory to a future concept of "emergent" or "organic" evolution, as it was proposed in 1923 by Lloyd Morgan. "Emergence" means that in each step of the evolutionary process something new comes into existence. It does not merely " result" by mechanic necessity from past conditions. This concept of "emergent" evolution vindicated the positive evaluation of Darwinism by the group of *Lux Mundi*, who had celebrated the new theory for doing away with the God of deism who had been responsible for the beginnings only, while now God could be seen to be active in every new turn of the evolutionary process. The concept of "emergent" evolution overcame the mechanistic, reductionistic way of describing Darwin's theory. And the tendency to emphasize the element of the new in the sequence of evolving forms of life was further strengthened by the realization that major steps in the evolutionary process need "fulgurations" of new schemes of organization rather than a sequence of small steps of cumulative variations.

❖ After providing the stage for a theological discussion of evolution, I now turn to the crucial issue of whether a theological appropriation of the doctrine of evolution can do justice to the Genesis account of the creation of animal species by God. In the third section of this paper the same question will be asked with regard to the human race. What has been said so far on the further development and refinement of the theory of evolution since Darwin, will prove helpful in the attempt to answer both these questions.

When we turn to the Biblical account of creation, the first thing must be to remind ourselves that the Biblical texts are historical documents and have to be interpreted in terms of what they were trying to say at the time of their composition. This principle of historical interpretation of the Bible is the core issue in all discussions with creationists. Historical interpretation reads the Biblical affirmations relative to the time of their writing, to the concerns of their authors at the time of their writing, and to the knowledge they had at their disposal. Such historical interpretation does not imply that the Biblical affirmations, being limited to their own time, had nothing to tell readers of a much later period. Rather, whatever they have to tell us, they convey precisely in their historical particularity. To the degree that their affirmations have universal significance, it is inherent in their historical particularity. Otherwise this significance would not be the meaning of the Biblical affirmations, but a meaning the modern interpreter reads into them. Furthermore, the historical reading of the Biblical affirmations does not preclude their appreciation as the Word of God; the Word that is addressing us like every generation of humanity. The Word of God expressed in the Biblical affirmations is, however, a unified entity. It is the Word of God that became incarnate in Jesus Christ. To read or hear the Bible as the Word of God is to relate each particular Biblical affirmation to the whole of the Biblical witness and to interpret the detailed, historically distinctive affirmations in that light. Therefore, reverence for the Bible as the Word of God does not stand in opposition to a careful historical scrutiny of each individual sentence.

With regard to the Biblical report on the creation of the world in the first chapter of Genesis, this means that we have to read its affirmations as witnessing to the God of Israel, the Creator of the world, through the use of the natural science of the sixth century BCE (i.e. Babylonian wisdom), in order to account for the sequence of creatures coming forth from God's creative activity. The relevance of this report in our present situation, then, is primarily the encouragement to use the science of our day in a similar way - for the purpose of witnessing today to the God of the Bible as Creator of the universe, as we know it. This is the authority of the Biblical report on the creation of the world. It calls us to attempt our own theology of nature, but in doing so to remain true to the peculiar and distinctive nature of the God of Israel, just as the authors of the priestly report on the creation of the World did in their own time.

The authority of the Biblical report does not require us to consider every detail as the last word on any given issue. Many statements are inevitably indebted to the limited knowledge of nature in the 6th century BCE. One example is the idea that the experience of rain is evidence of a huge supply of water in heaven above the clouds, comparable to the oceans down below. On this assumption, it is astonishing that the waters above the clouds normally remain separated from those beneath. This is explained by the idea (Gen. 1:6f.) that God created a vault to keep the waters above from pouring down. This mechanism is completely rational, and yet this beautiful and important detail can no longer be part of our conception of nature. The same applies to the assumption that all the different types of creatures, and especially all the different species of plants and animals were created in the beginning and remain permanently unchanged. This idea is an example of the mythical attitude of mind in early cultures, where generally, as Mircea Eliade told us, the world order was conceived as having been built in the "original time" without later change. By contrast, modern knowledge of nature possesses sufficient evidence for assuming that the natural world is in a continuous process of becoming. The continuous emergence of new types of creatures and the disappearance of others is part of that picture.

Does the modern conception of nature in terms of continuous change contradict the Biblical doctrine of creation? It is certainly at variance with the account, in the first chapter of Genesis, that the whole order of creation was produced in six days and continues to exist unchanged. Thus God laid down the order of heaven and earth and this became the model for the order of time, which repeats the first seven days every week. But with the Bible as a whole this is not the only conception of God's creative activity. Rather, in the prophetic writings we learn that God is continuously active in the course of history, and that once in awhile He creates something quite new (Is. 48:6f.). That is not to deny the creation of heaven and earth in the beginning. But second Isaiah takes that as an example of God's continuously creative activity. This, then, is the model of a continuous creation which is coextensive with the course of the world's history, and within which the creation of heaven and earth in the beginning was only the initial stage. This prophetic conception of God's creative activity is much closer to the modern understanding of nature in terms of a history of the universe than is the image of the six-day-creation in Genesis. Such a conception of continuous creation does not have difficulties with a doctrine of evolution, according to which the different species of animals emerge successively in the long process of life's history on earth.

There is one requirement, however, that must be met if the concept of evolution is to be compatible with a theology of nature based on the Biblical idea of God. That is the assumption of something new that occurs in each and every single event, but also in the emergence of new forms of

life in the process of evolution. This element of contingency was not in the focus of the early mechanistic interpretation of Darwinism, but it has been increasingly emphasized in the conception of epigenesis, which means the emergence of something new, and in the concept of emergent evolution.

Why is the element of contingency so important in a theological appropriation of the theory of evolution? The reason is that the Bible conceives of God's relationship to the world in terms of free, creative acts, in the course of history as well as with reference to the beginning of this world. In the first chapter of the Bible, this concern for God's freedom in his creative activity is expressed in the concept of the Divine word which brings about its effect in the most effortless way. In each creative act, God's freedom brings forth something new simply by His word. Therefore the history of the world is seen as an irreversible sequence of contingent events, notwithstanding all the regularities that can be observed in its course. Consequently, a concept of evolution in terms of a purely mechanical process would not be easy to reconcile with the Biblical idea of God's creative activity, while the concept of an epigenetic process of evolution with something new occurring in virtually every single event is perfectly compatible with it.

On the other hand, God's creative activity does not exclude the employment of secondary causes in bringing about God's creatures. In the 6th century priestly document on creation preserved in the first chapter of Genesis, the Creator tells the earth to bring forth vegetation (Gen. 1:11). And again it is the earth that is called upon to produce animals, especially mammals (Gen. 1:24). If our creationist friends today would adhere, in this case, to the letter of the Bible, they could have no objection against the emergence of organisms from inorganic matter, nor against the descent of the higher animals from those initial stages of life. In the Biblical view, such a mediation does not contradict the affirmation that the creatures are the work of God. For in the next verse it is explicitly said that God made the beasts and the cattle and everything that creeps upon the ground (Gen. 1:25). Of course, the Biblical text doesn't tell anything about the higher species of animals as having evolved from lower ones. But isn't that an issue of secondary importance, when compared with the question of whether the act of creation must be conceived of as an immediate action of God without any mediation by other creatures? This question, however, has been answered already. The immediacy of God's creative action with reference to God's creatures is not impaired by secondary causes, since their activity is not on the same level with that of the Creator.

❖ The case of the human being is a special one, because human persons are related to God in a special way. This fact is indicated by the importance of religion in one form or another throughout the history of the human race. Human self-consciousness seems closely connected with some form of

awareness of the divine. In the Bible, this close relationship to the origin of the universe is expressed in the idea that the human person has been created in the image of God. Therefore, the human being represents the Creator's own self with regard to the rest of God's creation. Doesn't that require that the human being was created by God alone, without the cooperation of other, earlier creatures? In the first chapter of the Bible no such cooperation is mentioned. Does that mean it is excluded?

The older report on the creation of human beings in the second chapter of Genesis does not justify such a suggestion, because it says that the human body was formed of "dust from the ground" (Gen. 2:7). That seems to be roughly equivalent to the role of the earth in the first chapter of Genesis, when God tells the earth to bring forth plants and animals. In the Biblical view the human body is taken from "the earth," just as was true with the animals. Therefore, our body is perishable, which is to say, it will return to the earth. Only the human spirit is said to come directly from God. As the second chapter of the Bible describes it, God breathes His breath into the figure He formed from the dust; He "breathed into his nostrils the breath of life" (Gen. 2:7). Correspondingly, with our last breath we return the gift of the spirit to God, as the psalm says. According to the Gospel of Luke, Jesus quoted this psalm when he died on his cross: "Into thy hand I commit my spirit" (Ps. 31:5; Luke 23:46). In the moment of death the spirit or breath gets separated from the body, and, as Ecclesiastes says, the dust returns to the earth, to what was, and the spirit returns to God who gave it" (Eccl. 12:7).

Does that mean that we are allowed to think of the human body as coming from the process of evolution of animal life, but not so of the human soul and spirit? This could seem to be required by the older creation story when it says that the Creator breathes the breath of life into the figure formed from clay and thereby man became a living being (Gen. 2:7). The Hebrew term here is *nefesh hayah*, and *nefesh* was often translated as "soul." Thus God is presented here as creating the human soul by breathing the spirit of life into the nostrils of the human body. It was from this sentence that the old Christian creationism of the Patristic period derived its theory about the origin of the human soul. While the body of each new individual was considered to come from the chain of propagation, each individual soul was believed to be added to the body by the Creator Himself. But this Patristic creationism presupposed an independent status of the soul as compared to the body, an idea that is in keeping with Platonism, but not with the Hebrew Scriptures. In the Old Testament *nefesh hayah*, which we translated by the term "soul," is not independent of the body, but rather the principle of its life, though not the origin of life itself. The *nefesh* is only the continuous hunger and thirst for life. The root meaning of the word is "throat." It is in constant need of the spirit of God, that productive breath or wind which animates the soul and through the

soul its body. The origin of life, then, is finally the divine spirit and not the human soul. It is only through the spirit that the human being becomes a "living soul," as the phrase in the creation story goes.

To be a "living soul," however, is not a distinctive prerogative of the human being. According to the creation story in the first chapter of Genesis, the "breath of life" is in all the animals, the beasts on the ground, the birds in the air (Gen. 1:30). This corresponds exactly to the idea in the earlier report on the creation of man, where God breathes the breath of life into the figure of clay so that it comes alive. If the animals have the breath of life within themselves, although they are products of the earth which was summoned by the Creator to bring them forth, then there is no difference between this creation and the creation of the human being, with regard to its description as "living soul," or *nefesh hayah*. The difference between the human being and other animals is not that the human being has a "living soul," but that it is destined to exist in a particular relationship to God, so that it is called on to represent the Creator Himself with regard to the animal world and even with regard to the earth (Gen. 1:26).

The excursion into Biblical exegesis was necessary to meet the charge of modern creationists that the doctrine of evolution, and especially the derivation of the emergence of the human race from the evolutionary process of animal life, contradicts the biblical creation stories. When in the Bible animal life is seen as a product of the earth, and the formation of human life as "living soul" is understood as analogous to animal life, then there is no reason why the human being should not have emerged from the evolution of animal life. The idea of evolution as such is a modern concept and cannot be derived from Biblical conceptions. But it is not opposed to the basic concerns of the Biblical conceptions of the origin of animal life and of human life. This can be affirmed as long as the modern idea of evolution does not exclude the creative divine activity within the entire process of evolution.

The doctrine of evolution is open to a theological interpretation when it is conceived not in terms of a mechanical process (based on the principle of natural selection), but as describing a process of emergence, in the course of which the productivity of life continuously produces something new. The element of contingency in this concept of emergent evolution secures its openness to the creative activity of God in this process. That each form of life can be understood as a creature of God is not dependent on the idea of purpose, the assumption of a purposeful adaptation of each species to the conditions of its survival in its environment. In earlier times it was assumed that such purposeful adaptation presupposes and demonstrates the intelligent will of the Creator and is not reducible to other causes. It was this assumption that Darwin destroyed by explaining the adaptation of a species to its environment as a result of natural selection. But the theory of

natural selection need not exclude the continuous activity of the Creator in the very productivity of life. The notion of the superabundant creativity of life is not an alternative to the creative action of God any more than is the productivity of the earth, which, in the Biblical creation story, is called upon by God to bring forth vegetation and even animals. The spontaneous creativity of life is the form of God's creative activity.

In a modern perspective, self-organization is characteristic of life at all levels of evolution. It accounts for spontaneity in all forms of life, and it is in this principle of spontaneous self-organization that we have to perceive the roots of human subjectivity. Self-organization is the principle of freedom and of superabundance in the creative advance of the evolutionary process. Human self-consciousness is its highest manifestation so far as we can see, as it allows us to integrate all other consciousness into the unity of our individual selves. Self-consciousness itself is not a given fact, however. In each individual life history it arises from the early stages of the development of our consciousness. Self-consciousness itself is already a product of the creativity of life within each one of us, a product of the creative activity of the divine spirit.

The creative self-organization of life in the process of evolution from inorganic matter to the first organisms, corresponds to the blowing of the divine wind, the spirit of God that breathes life into ever new creatures and thus blows through the evolution of life until it overcomes all perishableness in the resurrection of Jesus Christ. The death of individuals is due, according to the Biblical witness, to their limited share in the divine spirit (Gen. 6:3). To Jesus, however, though a finite being himself, the spirit of life was given "without measure" (John 3:34). Therefore he was raised from the dead by the power of the spirit and transformed into a spiritual body (1 Cor. 15:44sqq.), which is to say, into imperishable life, which is imperishable because of its unbroken participation in the divine spirit who is the source of all life.

A Christian account of the evolution of life as expression of the divine spirit blowing through His creation cannot abstain from some reference to the eschatological resurrection of the dead, the climax of the creative activity of the divine spirit that was first realized in the resurrection of Jesus. This climactic resurrection is meant to embrace human beings in general by communion with Jesus and even, according to Paul, the world of other creatures, because "creation itself will be set free from its bondage of decay and obtain the glorious liberty of the children of God" (Romans 8:21).