THE PONTIFICAL ACADEMY OF SCIENCES

EXTRA SERIES 33

Address of His Holiness Benedict XVI to the Members of the Pontifical Academy of Sciences on the Occasion of their Plenary Assembly

Discorso del Santo Padre Benedetto XVI ai partecipanti alla Plenaria della Pontificia Accademia delle Scienze

Statement by the Pontifical Academy of Sciences on Current Scientific Knowledge on Cosmic Evolution and Biological Evolution

Revised draft of 24 January 2009 by Prof. W. Arber (2), with suggestions made the Academicians N. Cabibbo, P. Léna (2), Y. Manin, J. Mittelstrass, W. Phillips, P. Raven (2), I. Rodríguez-Iturbe, M. Singer, W. Singer, A. Szczeklik (2), R. Vicuña, and A. Zichichi

Summary

by Prof. Christian de Duve

VATICAN CITY
2008

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ADDRESS OF HIS HOLINESS BENEDICT XVI TO THE MEMBERS OF THE PONTIFICAL ACADEMY OF SCIENCES ON THE OCCASION OF THEIR PLENARY ASSEMBLY

Clementine Hall
Friday, 31 October 2008

Distinguished Ladies and Gentlemen,

I am happy to greet you, the members of the Pontifical Academy of Sciences, on the occasion of your Plenary Assembly, and I thank Professor Nicola Cabibbo for the words he has kindly addressed to me on your behalf.

In choosing the topic *Scientific Insight into the Evolution of the Universe and of Life*, you seek to focus on an area of enquiry which elicits much interest. In fact, many of our contemporaries today wish to reflect upon the ultimate origin of beings, their cause and their end, and the meaning of human history and the universe.

In this context, questions concerning the relationship between science's reading of the world and the reading offered by Christian Revelation naturally arise. My predecessors Pope Pius XII and Pope John Paul II noted that there is no opposition between faith's understanding of creation and the evidence of the empirical sciences. Philosophy in its early stages had proposed images to explain the origin of the cosmos on the basis of one or more elements of the material world. This genesis was not seen as a creation, but rather a mutation or transformation; it involved a somewhat horizontal interpretation of the origin of the world. A decisive advance in understanding the origin of the cosmos was the consideration of being *qua* being and the concern of metaphysics with the most basic question of the first or transcendent origin of participated being. In order to develop and evolve, the world must first *be*, and thus have come from nothing into being. It must be created, in other words, by the first Being who is such by essence.

To state that the foundation of the cosmos and its developments is the provident wisdom of the Creator is not to say that creation has only to do with the beginning of the history of the world and of life. It implies, rather, that the Creator founds these developments and supports them, underpins them and sustains them continuously. Thomas Aquinas taught that the notion of creation must transcend the horizontal origin of the unfolding of events, which is history, and consequently all our purely naturalistic ways of thinking and speaking about the evolution of the world. Thomas observed that creation is neither a movement nor a mutation. It is instead the foundational and continuing relationship that links the creature to the Creator, for he is the cause of every being and all becoming (cf. *Summa Theologiae*, I, q. 45, a. 3).

To "evolve" literally means "to unroll a scroll", that is, to read a book. The imagery of nature as a book has its roots in Christianity and has been held dear by many scientists. Galileo saw nature as a book whose author is God in the same way that Scripture has God as its author. It is a book whose history, whose evolution, whose "writing" and meaning, we "read" according to the different approaches of the sciences, while all the time presupposing the foundational presence of the author who has wished to reveal himself therein. This image also helps us to understand that the world, far from originating out of chaos, resembles an ordered book; it is a cosmos. Notwithstanding elements of the irrational, chaotic and the destructive in the long processes of change in the cosmos, matter as such is "legible". It has an inbuilt "mathematics". The human mind therefore can engage not only in a "cosmography" studying measurable phenomena but also in a "cosmology" discerning the visible inner logic of the cosmos. We may not at first be able to see the harmony both of the whole and of the relations of the individual parts, or their relationship to the whole. Yet, there always remains a broad range of intelligible events, and the process is rational in that it reveals an order of evident correspondences and undeniable finalities: in the inorganic world, between microstructure and macrostructure; in the organic and animal world, between structure and function; and in the spiritual world, between knowledge of the truth and the aspiration to freedom. Experimental and philosophical inquiry gradually discovers these orders; it perceives them working to maintain themselves in being, defending themselves against imbalances, and overcoming obstacles. And thanks to the natural sciences we have greatly increased our understanding of the uniqueness of humanity's place in the cosmos.

The distinction between a simple living being and a spiritual being that is *capax Dei*, points to the existence of the intellective soul of a free transcendent

subject. Thus the Magisterium of the Church has constantly affirmed that "every spiritual soul is created immediately by God – it is not 'produced' by the parents – and also that it is immortal" (*Catechism of the Catholic Church*, 366). This points to the distinctiveness of anthropology, and invites exploration of it by modern thought.

Distinguished Academicians, I wish to conclude by recalling the words addressed to you by my predecessor Pope John Paul II in November 2003: "scientific truth, which is itself a participation in divine Truth, can help philosophy and theology to understand ever more fully the human person and God's Revelation about man, a Revelation that is completed and perfected in Jesus Christ. For this important mutual enrichment in the search for the truth and the benefit of mankind, I am, with the whole Church, profoundly grateful".

Upon you and your families, and all those associated with the work of the Pontifical Academy of Sciences, I cordially invoke God's blessings of wisdom and peace.

DISCORSO DEL SANTO PADRE BENEDETTO XVI AI PARTECIPANTI ALLA PLENARIA DELLA PONTIFICIA ACCADEMIA DELLE SCIENZE

Sala Clementina
Venerdì, 31 ottobre 2008

Illustri signore e signori,

sono lieto di salutare voi, membri della Pontificia Accademia delle Scienze, in occasione della vostra assemblea plenaria, e ringrazio il professor Nicola Cabibbo per le parole che mi ha cortesemente rivolto a vostro nome.

Nella scelta del tema "Comprensione scientifica dell'evoluzione dell'universo e della vita", cercate di concentrarvi su un'area di indagine che solleva grande interesse. Infatti, oggi molti nostri contemporanei desiderano riflettere sull'origine fondamentale degli esseri, sulla loro causa, sul loro fine e sul significato della storia umana e dell'universo.

In questo contesto, è naturale che sorgano questioni relative al rapporto fra la lettura che le scienze fanno del mondo e quella offerta dalla rivelazione cristiana. I miei predecessori Papa Pio XII e Papa Giovanni Paolo II hanno osservato che non vi è opposizione fra la comprensione di fede della creazione e la prova delle scienze empiriche. Agli inizi la filosofia ha proposto immagini per spiegare l'origine del cosmo sulla base di uno o più elementi del mondo materiale. Questa genesi non era considerata come una creazione, quanto piuttosto come una mutazione o trasformazione. Implicava una interpretazione in qualche modo orizzontale dell'origine del mondo. Un progresso decisivo nella comprensione dell'origine del cosmo è stato la considerazione dell'essere in quanto essere e l'interesse della metafisica per la questione fondamentale dell'origine prima e trascendente dell'essere partecipato. Per svilupparsi ed evolversi il mondo deve prima *essere*, e quindi essere passato dal nulla all'essere. Deve essere creato, in altre parole, dal primo Essere che è tale per essenza.

Affermare che il fondamento del cosmo e dei suoi sviluppi è la sapienza provvida del Creatore non è dire che la creazione ha a che fare soltanto con l'inizio della storia del mondo e della vita. Ciò implica, piuttosto, che il Creatore fonda questi sviluppi e li sostiene, li fissa e li mantiene costantemente. Tommaso d'Aquino ha insegnato che la nozione di creazione deve trascendere l'origine orizzontale del dispiegamento degli eventi, ossia della storia, e di conseguenza tutti i nostri modi meramente naturalistici di pensare e di parlare dell'evoluzione del mondo. Tommaso ha osservato che la creazione non è né un movimento né una mutazione. È piuttosto il rapporto fondazionale e costante che lega le creature al Creatore poiché Egli è la causa di tutti gli esseri e di tutto il divenire (cfr. *Summa theologiae*, I, q. 45, a.3).

"Evolvere" significa letteralmente "srotolare un rotolo di pergamena", cioè, leggere un libro. L'immagine della natura come libro ha le sue origini nel cristianesimo ed è rimasta cara a molti scienziati. Galileo vedeva la natura come un libro il cui autore è Dio così come lo è delle Scritture. È un libro la cui storia, la cui evoluzione, la cui "scrittura" e il cui significato "leggiamo" secondo i diversi approcci delle scienze, presupponendo per tutto il tempo la presenza fondamentale dell'autore che vi si è voluto rivelare. Questa immagine ci aiuta a comprendere che il mondo, lungi dall'essere stato originato dal caos, assomiglia a un libro ordinato. È un cosmo. Nonostante elementi irrazionali, caotici e distruttivi nei lunghi processi di cambiamento del cosmo, la materia in quanto tale è "leggibile". Possiede una "matematica" innata. La mente umana, quindi, può impegnarsi non solo in una "cosmografia" che studia fenomeni misurabili, ma anche in una "cosmologia" che discerne la logica interna visibile del cosmo. All'inizio potremmo non riuscire a vedere né l'armonia del tutto né delle relazioni fra le parti individuali né il loro rapporto con il tutto. Tuttavia, resta sempre un'ampia gamma di eventi intellegibili, e il processo è razionale poiché rivela un ordine di corrispondenze evidenti e finalità innegabili: nel mondo inorganico fra microstruttura e macrostruttura, nel mondo animale e organico fra struttura e funzione, e nel mondo spirituale fra conoscenza della verità e aspirazione alla libertà. L'indagine filosofica e sperimentale scopre gradualmente questi ordini. Percepisce che operano per mantenersi in essere, difendendosi dagli squilibri e superando ostacoli. Grazie alle scienze naturali abbiamo molto ampliato la nostra comprensione dell'unicità del posto dell'umanità nel cosmo.

La distinzione fra un semplice essere vivente e un essere spirituale, che è *capax Dei*, indica l'esistenza dell'anima intellettiva di un libero soggetto trascendente. Quindi, il Magistero della Chiesa ha costantemente affermato

che “ogni anima spirituale è creata direttamente da Dio – non è "prodotta" dai genitori – ed è immortale” (*Catechismo della Chiesa cattolica*, n. 366). Ciò evidenzia gli elementi distintivi dell’antropologia e invita il pensiero moderno ad esplorarli.

Illustri accademici, desidero concludere ricordando le parole che vi rivolse il mio predecessore Papa Giovanni Paolo II nel novembre del 2003: “Sono sempre più convinto che la verità scientifica, che è di per sé una partecipazione alla Verità divina, possa aiutare la filosofia e la teologia a comprendere sempre più pienamente la persona umana e la Rivelazione di Dio sull’uomo, una rivelazione compiuta e perfezionata in Gesù Cristo. Per questo importante arricchimento reciproco nella ricerca della verità e del bene dell’umanità, io, insieme a tutta la Chiesa, sono profondamente grato”.

Su di voi, sulle vostre famiglie e su tutti coloro che sono associati all’opera della Pontificia Accademia delle Scienze invoco di cuore le benedizioni divine di sapienza e di pace.

STATEMENT BY THE PONTIFICAL ACADEMY OF SCIENCES ON CURRENT SCIENTIFIC KNOWLEDGE ON COSMIC EVOLUTION AND BIOLOGICAL EVOLUTION

REVISED DRAFT OF 24 JANUARY 2009 BY PROF. W. ARBER (2),
WITH SUGGESTIONS MADE THE ACADEMICIANS N. CABIBBO, P. LÉNA (2),
Y. MANIN, J. MITTELSTRASS, W. PHILLIPS, P. RAVEN (2),
I. RODRÍGUEZ-ITURBE, M. SINGER, W. SINGER, A. SZCZEKLIK (2),
R. VICUÑA, AND A. ZICHICHI

The Pontifical Academy of Sciences devoted its Plenary Session of 31 October–4 November 2008 to the subject: 'Scientific Insights into the Evolution of the Universe and of Life'. The Plenum was attended by 45 members of the Academy and by 14 invited guests. Lectures were given by 23 members and 8 additional lectures were given by invited experts. Ample time was devoted to discussions.

The chosen subject is very topical for the sciences as well as for philosophy and theology and it is also of relevance for the general public. A majority of the lectures and debates concentrated on presenting contemporary scientific insights into the evolutionary processes and on integrating these insights into our common world-view. The Academy also provided a platform for a discussion on the relationship between acquired scientific knowledge and other branches of knowledge, including a philosophical approach and traditional wisdom such as that to be found in Biblical writings.

On the first day of the session, the Academy specifically addressed established knowledge, theories, models and open questions relating to cosmic evolution. Ever more powerful instruments (telescopes, etc.) allow us to explore developments that occurred in the far past despite the limitation imposed by the speed of light. Another frontier of scientific investigation is penetrating ever smaller dimensions, revealing the laws of the cosmic micro-

world. Recent investigations both in the very big and in the very small confirm and strengthen the previously reached scientific consensus that the cosmic evolution of galaxies and of matter is an undeniable fact. The cosmos and time may indeed have a temporal origin, contrary to ancient Greek opinion (with the exception of Plato – *Timaeus*) which generally regarded them as eternally cyclical, without a beginning and an end. The exact time of that origin is subject to a small but fundamental uncertainty.

Several lectures raised questions about the existence of life in other parts of the universe. Theories and logical speculations attempt to provide answers to these pertinent questions. However, until appropriate observations and investigations in our galaxy (it may be observed that over 300 extra-solar planets have already been discovered), and perhaps in the future in other galaxies, are possible, science cannot provide solid answers to these questions. The origin of life on earth was also discussed, with an exposition of recent progress in the field, in the light of what man is learning about our galaxy as well.

We can now understand biological evolution at the molecular level. Hypotheses that had been presented earlier have been validated with novel research strategies. Genetic variation, the driving force of biological evolution, is shown to involve a number of different molecular mechanisms. Genetics as well as computational comparison of DNA sequences allow us to explore these mechanisms, which can be classified into three natural strategies (local DNA sequence changes, intragenomic rearrangement of DNA segments, and acquisition of foreign DNA segments) of different evolutionary qualities. Interestingly, both specific products of so-called evolution genes and a number of non-genetic elements contribute to overall spontaneous mutagenesis, and very low rates of mutagenesis underlie the genetic stability of living organisms.

Natural selection results from the way by which living organisms deal with encountered living conditions to which both the physicochemical environment and the presence of other organisms in a given ecosystem contribute. Most of the prevalent substrates for natural selection are phenotypes resulting from the presence and activities of expressed gene products. However, particularly for eukaryotic organisms, genome organisation and the compacting of chromosomes into chromatin can also contribute to the outcome of natural selection. The presence of evolution genes determining the evolutionary fitness of living organisms is selected at the population level by second-order selection. Positive selective pressure is also exerted by long-term symbiotic associations between different kinds of microorganisms – for

example between humans and several kinds of microorganisms. Organelles, such as mitochondria and chloroplasts, testify to the evolutionary importance of symbiotic cohabitation.

The Plenum devoted ample time to primate and in particular to human evolution. In this evolutionary pathway a remarkable increase of the size of the brain has occurred. Many novel genes that have been added during the course of evolution are expressed in the brain. In addition, importance can be attributed to the development and establishment of a complex neuronal network during childhood. All of these evolutionary and developmental changes are generally seen as a basis for the capacities for consciousness, intelligence and freedom, and their possible development. These attributes allowed human beings to develop what is generally known as 'culture'.

Since cultural evolution facilitates the organisation of human lives, the pressure of natural selection on a number of distinct traits in the human population is diminished, although, of course, it still acts on many other features. In view of this situation, the Academy calls for humanity to exercise responsibility when intervening in the natural evolutionary processes and to use scientific knowledge and its technological applications to safeguard the conditions for survival of all species and, in particular, to assure the dignity and the wellbeing of humans.

We have to be aware that the impact of human activities on our environment is not unique but is now as great as any factor affecting living things during the whole period of the existence of life on earth. Many other living beings, including bacteria, which are not provided with consciousness, may also contribute to changing in a considerable way the environment and thus also the pressure of natural selection. The Plenum noticed a remarkable example of this situation: it is generally thought that early life on earth was largely anaerobic as long as the atmosphere contained no or very little oxygen. This changed after photosynthesis was developed through the biological evolution of microorganisms and, in particular, when plants acquired the capacity for photosynthesis. It is only thanks to this evolutionary progress that aerobic life became possible, including that of higher animals and human beings.

This striking example of interdependencies between biological and geological evolution on the planet should not be seen as a justification for human society to abuse precious natural resources and to cause climate change by its modern lifestyle; indeed, quite the contrary. Since we are the only being with consciousness that is in the position of affecting the condition of life on earth as a whole, we have a special responsibility, clearly outlined in Holy Scripture, to care for the earth.

It is largely due to considerable improvements in human living conditions – among which we may also list the strong improvement in therapeutic and preventive medical care – that in the last hundred years both human life expectancy and the global density of the human population have strongly increased. Justice at a global level that provides sufficient food and water to all, without injuring the environment, is an increasing imperative.

On several occasions the role of chance was addressed by the Plenum, in relation to both cosmic and biological evolution. According to present scientific knowledge, chance is required in natural reality in order for it to be prepared for rapid adaptation to newly developing situations. In biological evolution, partial randomness in the generation of genetic variants may render populations of organisms more adaptable to changing living conditions.

From the natural scientist's point of view, natural evolutionary processes largely reflect self-organisation, which depends on the intrinsic properties of matter and energy. This holds for cosmic and for biological evolution, which must cover about 15,000 and almost 4,000 million years respectively.

It is important for scientific knowledge on evolution to become integrated into our world-view and for our world-view to be steadily updated. The extraordinary progress in our understanding of evolution and the place of man in nature should be shared with everyone. This will help to guide humans and the next generations in decisions that contribute to cultural evolution, including agricultural practices, societal developments, medically-relevant activities and environmental emissions, based on reason, fairness and justice. A wise use of available scientific knowledge not exclusively for the benefit of the human population but also for the safeguarding of a rich biodiversity and of natural resources can contribute significantly to a harmonious evolution of life on our planet and the wellbeing of future generations. Furthermore, scientists have a clear responsibility to contribute to the quality of education, especially as regards the subject of evolution, and to the quality of knowledge that education conveys.

The plenary session confirmed the Pontifical Academy of Sciences in its awareness of a remarkable strengthening in recent years of our scientific knowledge about cosmic and biological evolution. One could see in these evolutionary processes a confirmation of the theological concept of *creatio continua* (*creatio* and *conservatio)* which states that creation is a permanent process of participation of being by the Being by essence, who deserves our respect and our praise. Evolution and creation fill us with wonder and awe and remind us of the Biblical benediction: 'And God saw every thing that He had made, and, behold, it was very good' (Gen 1:31).

SUMMARY

by Prof. Christian de Duve

The Pontifical Academy of Sciences devoted its Plenary Session of 31 October-4 November 2008 to the subject: 'Scientific Insights into the Evolution of the Universe and of Life.'

The Academy offered a unique setting and intellectual climate for the chosen topic, which is of burning interest – and an occasional source of dispute – for scientists, philosophers, and theologians alike, as well as for the general public. It was particularly valuable to have representatives of all major scientific disciplines and of philosophy and theology gathered together and exchanging views in an atmosphere of intellectual freedom and mutual respect.

There was little disagreement on major issues. The participants unanimously accepted as indisputable the affirmation that the Universe, as well as life within it, are the products of long evolutionary histories. They rejected as objectively untenable the so-called 'creationist' view based on a literal interpretation of the biblical account of Genesis, a view not to be confused with the belief, legitimately held by many, in a creator God. Benedict XVI in his opening address to the participants proposed a valuable approach based on a metaphysical interpretation of the creation clearly different from that of the 'Creationists': 'A decisive advance in understanding the origin of the cosmos was the consideration of being *qua* being and the concern of metaphysics with the most basic question of the first or transcendent origin of participated being. In order to develop and evolve, the world must first *be*, and thus have come from nothing into being. It must be created, in other words, by the first Being who is such by essence.'

Several contributions reviewed recent developments in cosmology. Attention was drawn to a number of still unsolved problems, including dark matter, dark energy, black holes, and the possibility that our Universe

may be only one among a huge number of universes (multiverse), perhaps the only one that happens by chance to have physical constants such that complex forms of matter, including living beings, can arise. The latter hypothesis, however, is purely speculative and may well remain so, because of a lack of means of either proving or disproving it.

Special attention was paid to the solar system and, within this system, to planet Earth and the emergence of life on it. The question was raised whether other such systems, possibly including planets bearing life and, perhaps, intelligence, might exist elsewhere in our galaxy or in others. This has become a major subject of astronomical research. More than 300 planets have been discovered around nearby stars and intense efforts are made to devise technologies that would allow signs of life to be detected. The search for extraterrestrial intelligence (SETI) has been underway for some time and is being expanded, without, however, having yielded any positive result so far.

Many discussions were devoted to the origin and evolution of life. It was generally admitted that all known living beings, including humans, descend from a single ancestral form of life that appeared on Earth several billion years ago. How this form originated is not known but is believed by a majority of experts to have involved special chemical reactions that were rendered possible, perhaps even imposed, by the physical-chemical conditions under which they took place. Particularly impressive in this respect is the recent discovery that a number of typical building blocks of life, including sugars, amino acids, and nitrogenous bases, arise spontaneously, together with numerous other organic compounds, in many parts of the Universe. Not all scientists, however, believe this remarkable fact to be relevant to the origin of life.

A key event in the long history of life on Earth was the appearance, between 2.4 and 2.0 billion years ago, of molecular oxygen, a product of photosynthetic organisms and an essential prerequisite to the formation of aerobic forms of life, including all animals (and humans). Another decisive event was the development of eukaryotic cells which eventually gave rise to the multicellular plants, fungi, animals, and humans. Although many details remain to be clarified, the actual occurrence of biological evolution is no longer just a theory, strongly suggested by fossil evidence, but not conclusively demonstrated by it. Evolution is now supported by overwhelming molecular proofs and has acquired the status of established fact. In the words of His Holiness John Paul II, it is “more than a hypothesis”.

There was also wide agreement on the central role played in biological evolution by Darwinian natural selection, defined as a natural process that

obligatorily brings out, from a collection of accidentally produced genetic variants, those most apt to survive and, especially, to produce progeny under prevailing conditions. A number of contributions did, however, underline the need to refine some of the conceptual bases of this theory in the light of recent findings. The genetic variations subject to natural selection may be of different type, involving, not only changes in DNA sequences, but also intragenomic reorganization of genetic fragments, acquisition of foreign DNA, as well as chemical modifications of the DNA and changes in chromosome organization. One also has to take into account the hierarchical organization of genes, their mutability and its control, and the presence of so-called 'evolution genes.' Attention must also be given to non-Darwinian mechanisms of evolution, such as genetic drift, by way of neutral or near-neutral mutations, and the direct inheritance of certain molecular shapes. It must also be recognized that the conditions that influence natural selection are not only physical and chemical, but also biological, including entire eco-systems. These factors all tend to modulate the role of chance in evolution and to introduce more necessity in the process than was believed by earlier evolutionists.

On the other hand, no one, at least among the scientists, defended the recently advocated theory of 'intelligent design', according to which certain evolutionary events could not have taken place without the intervention of some higher influence, of which no evidence can be found in nature. Several of the arguments cited in support of this theory were shown to ignore recent findings. In particular, the theory was rejected as intrinsically non-scientific, resting, as it does, on the *a priori* contention, neither provable nor disprovable, that certain events cannot be naturally explained. These views did not satisfy some theologians who stressed the role of design in creation, an affirmation which, in turn, raised the questions of where and how design is manifested. The issue was not settled during the meeting.

These discussions automatically brought to the fore the subject of human manipulation of the selection process, including the much-debated topic of genetically modified organisms (GMOs). It was pointed out that humans did not await the development of genetic engineering to start interfering with life on Earth. They have, ever since the inauguration of agriculture and animal breeding, some ten thousand years ago, manipulated living organisms for their own benefit, empirically generating plant and animal species that are totally different from their wild ancestors and which have, thanks to their much higher yields, allowed the feeding of

many more people than could otherwise have been sustained. In this context, the development of GMOs by rationally designed manipulations could be seen as a distinct improvement over earlier empirical techniques, of great potential benefit for the feeding of the expanding human population. Nevertheless, this technology is vigorously opposed as 'anti-natural' by many defenders of the environment.

The advent of humankind attracted a great deal of interest. The recent history of hominization was reviewed, together with the molecular evidence establishing the single origin of all the human populations that exist on Earth today. Special attention was paid to the astonishing increase in size (almost four-fold) and complexity of the brain that accompanied, in a span of only a few million years, the conversion of chimpanzee-like ancestors into fully developed human beings. Several neurobiologists and cognition experts elaborated on the anatomical and functional correlates of these remarkable changes. The new capabilities of these changes, in relation, among others, to human freedom and the human intellective soul, were underscored by several speakers.

Particularly highlighted was the faculty of the human brain to undergo, mostly during the first years of its development, a considerable amount of epigenetic reprogramming of its genetically determined basic structure. The decisive role of education in this process was emphasized. This consideration has become acutely urgent for the future of humanity and of much of the rest of the living world, which is gravely threatened by the consequences of the inordinate evolutionary success (largely imputable to natural selection but also to culture) of the human species. For this threat to be averted, some of the unfavourable ingrained traits of human nature (which, from a theological point of view, could be viewed as related to original sin), must be corrected by education and, for those who believe, by the grace and love of God. Religions can be particularly influential in this respect and thereby bear a crucial responsibility in changing the future of the world for the better and, perhaps, saving humanity from extinction.

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But the big problem is that were God not to exist and were he not also the Creator of my life, life would actually be a mere cog in evolution, nothing more; it would have no meaning in itself. Instead, I must seek to give meaning to this component of being. Currently, I see in Germany, but also in the United States, a somewhat fierce debate raging between so-called "creationism" and evolutionism, presented as though they were mutually exclusive alternatives: those who believe in the Creator would not be able to conceive of evolution, and those who instead support evolution would have to exclude God. This antithesis is absurd because, on the one hand, there are so many scientific proofs in favour of evolution which appears to be a reality we can see and which enriches our knowledge of life and being as such. But on the other, the doctrine of evolution does not answer every query, especially the great philosophical question: where does everything come from? And how did everything start which ultimately led to man? I believe this is of the utmost importance. This is what I wanted to say in my lecture at Regensburg: that reason should be more open, that it should indeed perceive these facts but also realize that they are not enough to explain all of reality. They are insufficient. Our reason is broader and can also see that our reason is not basically something irrational, a product of irrationality, but that reason, creative reason, precedes everything and we are truly the reflection of creative reason. We were thought of and desired; thus, there is an idea that preceded me, a feeling that preceded me, that I must discover, that I must follow, because it will at last give meaning to my life. This seems to me to be the first point: to discover that my being is truly reasonable, it was thought of, it has meaning. And my important mission is to discover this meaning, to live it and thereby contribute a new element to the great cosmic harmony conceived of by the Creator.

(Meeting of the Holy Father Benedict XVI with the Clergy of the Dioceses of Belluno-Feltre and Treviso, Church of St Justin Martyr, Auronzo di Cadore, Tuesday, 24 July 2007).