SCIENCE NEVER ENDS:
A NEW PARADIGM IS BEING BORN IN BIOLOGY

RAFAEL VICUÑA

Does science have an end?

The spiraling advances in our knowledge of the natural world appear to drive the paradox that sooner or later science will no longer have questions left to answer. Distinguished thinkers thought that such a transcendental moment had already arrived. Of note is the case of physicist Albert Michelson, who in 1894, upon delivering the main address during the dedication of the Ryerson Physical Laboratory at the University of Chicago, declared that the more important fundamental laws and facts of physical science had all been discovered. According to Michelson, future research would be oriented towards the application of these principles and to perfect the precision of measurements. The same kind of assertion had been foretold by the eminent Lord Kelvin. A few years following the predictions of Michelson and Kelvin, the revolutionary theories of relativity and quantum mechanics emerged and completely changed the outlook on how the universe is viewed. Ironically, the experiments of Michelson relating to the speed of light helped to inspire Einstein's special theory of relativity.

In a book published in 1996, entitled *The end of science*,[1] the author John Horgan discusses the limits of knowledge with scholars from a broad range of disciplines. Among the interviewees is Gunther Stent, who has been one of the foremost proponents of 'the end of science'. Born in 1924 in Germany, Gunther Stent settled fourteen years later in Chicago, where he would later receive a Ph.D. in Chemistry from the University of Illinois. He was one of several physicists attracted to the biological sciences after

[1] Horgan, J., *The end of science*. Broadway Books, New York, 1996.

reading the now classic work *What is life*[2] written by Erwin Schrödinger. Gunther Stent, together with Max Delbrück, Leo Szilard, Francis Crick, Rosalin Franklin and Maurice Wilkins, among others, left the scientific discipline in which they had been trained to tackle the mysteries of living organisms. Stent was soon working along with Delbrück at the California Institute of Technology. Both were members of the famous *Phage Group*, which also included Salvador Luria, Alfred Hershey and James Watson. Later, in 1952, he would establish himself at the University of California at Berkeley, where he works until this day. There he founded the Department of Molecular Biology, and later he entered the fields of neurobiology and philosophy of science.

In 1969, Stent published *The coming of the golden age: a view of the end of progress*,[3] in which he develops the hypothesis that reality possesses limits and therefore soon nothing important will remain to be discovered. He utilized the fields of anatomy and geography as examples of scientific endpoints. According to Stent, chemistry had already reached its heights in the 30s when Linus Pauling demonstrated that every molecular interaction could be understood in terms of quantum mechanics. For their part, physicists had already described the physical universe, from the microcosmos of quarks and electrons to the macrocosmos of planets, stars and galaxies. Furthermore, a consensus had been reached in which the universe exploded about 15 billion years ago and that all matter is governed by four forces: gravity, electromagnetism and the weak and strong nuclear forces. The field of biology would be left with only three fundamental problems to explore: the origin of life on Earth, embryonic development and the processing of information by the brain. According to Gunther Stent, students of the nervous system would form the avant-garde of biological research, with the challenging perspective that the inability to even imagine any reasonable molecular explanation for consciousness offers some hope that new laws of physics might be revealed.

The remainder of the larger picture in the biological sciences had been clarified with the publication of the *Origin of the species by means of natural selection* by Darwin, the resolution of the DNA structure by Watson and Crick and the deciphering of the genetic code. These latter two discoveries

[2] Schrödinger, E., *What is life? The physical aspect of the living cell*. Cambridge, Cambridge University Press, 1944.

[3] Stent, G.S., *The coming of the golden age: a view of the end of progress*. The Natural History Press, Garden City, New York, 1969.

seemed not to have left room for new advances in the field of molecular biology, a premise which would lead Stent to publish in the journal *Science* in the year 1968 a provocative article entitled: 'That was the molecular biology that was'.[4] In the first paragraph of this article, Stent declared '... the approaching decline of molecular biology, only yesterday an avant-garde but today definitely a workaday field'.

Gunther Stent was not alone in the twentieth century with this fatalistic vision of science. Other protagonists included the physicist Leo Kodanoff and the former president of the American Association for the Advancement of Science, Bentley Glass, who observed that 'experiments of increasing costs are designed to solve more and more irrelevant details'.

A journey through the central dogma of molecular biology

About 34 years after the publication of *The coming of the golden age*, we could ask ourselves how accurate was Stent's prediction related to the end of molecular biology. The so-called central dogma of this discipline, enunciated by Francis Crick in the 60s, seems a viable reference point for a quick analysis on this matter. As it was written in its initial version, the dogma maintained that the flow of genetic information always goes from DNA to RNA and then to proteins. It also established that both DNA and RNA have capacity to replicate themselves.

Subsequent studies on the replication of the DNA confirmed what Watson and Crick predicted in their classic publication in the journal Nature in 1953:[5] 'It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material'. Although there has since been no discovery that could be classified as revolutionary in the field of DNA replication, the synthesis of this fundamental polymer has demonstrated to be extraordinarily more complex than initially imagined. In the bacterium *Escherichia coli*, for example, more than 50 proteins contribute to this process, including five enzymes (DNA polymerases) with the capacity to catalyze the synthesis of DNA. The most prominent of these, DNA polymerase III holoenzyme, is in charge of copying the bacterial chromosome in anticipation of cellular division, a task performed at the astounding speed of 700 nucleotides per second. The discovery of topoisomerases, enzymes that solve the problem of

[4] Stent, G.S., *Science* 160, 390-395, 1968.
[5] Watson, J. and Crick, F., *Nature* 171, 737-738, 1953.

the advancing DNA replication fork through two strands that are coiled around each other, also constitutes a conceptual novelty difficult to predict in the early 50s. In this respect, there are still important aspects to solve, particularly the mechanisms that regulate the process in higher cells.

In 1970, Howard Temin and David Baltimore demonstrated independently that the flow of information from DNA to RNA was not strictly unidirectional, as some viruses have an enzyme called reverse transcriptase that is able to copy DNA using RNA as template. These viruses, known as retroviruses, are of great importance to human health as they are responsible for AIDS and certain cancers. Both investigators received the Nobel prize in Medicine in 1975 for this discovery. Another enzyme possessing this reverse action is telomerase, which is of major importance in the synthesis of chromosomal ends and whose action is altered in cancer cells.

The central dogma also failed to predict two unexpected transformations which messenger RNA (mRNA) undergoes before the encoded information is translated into proteins. These alterations consist of the removal of multiple sections of internal sequences or introns, a phenomenon known as *splicing*, and in the chemical modification of the mRNA in a process called *editing*, which alters the information originally encoded by the DNA template. Both modifications to the mRNA, while not contradicting the dogma, certainly shake it in its foundations, to say the least. Today we are still baffled by the existence of splicing and editing, as it would seem a more efficient use of cellular energy if evolution had chosen to directly alter the chromosomal DNA instead of the mRNA. More recently, the phenomenon of trans-splicing has been uncovered. It consists of a covalent union of mRNA fragments originating from both DNA strands, extending the initial concept still further that a gene is a continuous segment of genetic information.[6]

But still, this is not the complete story. Studies on RNA splicing mechanisms lead in 1982 to the surprising discovery that some introns have the capacity to excise themselves without the participation of enzymes. This catalytic activity of introns was later found in several RNAs that participate in diverse pathways of cellular metabolism. Typical examples of these now called ribozymes are the RNAs catalyzing peptide linking during protein synthesis and those which are responsible for the processing of transfer RNA (tRNA) precursors. It was for their work in this field that Thomas

[6] Labrador, M., Mongelard, F., Plata-Rengifo, P., Baxter, E.M., Corces, V.G. and Gerasimova, T.I. *Nature* 409, 1000, 2001.

Cech and Sidney Altman were awarded with the Nobel prize in Chemistry in 1989. In recent years investigators have selected synthetic RNAs of such catalytic versatility, that the hypothesis that ribozymes must have played a fundamental role in the first evolutionary stages of the life on Earth has been given a strong fortification. Examples of ribozyme activities generated in the laboratory by random sequence selection include phosphodiester cleavage, RNA ligation, RNA phosphorylation, RNA aminoacylation, peptide bond formation, glycosidic bond formation, RNA alkylation and cyclic phosphate hydrolysis, among others.[7] It has further been demonstrated that under specific conditions, RNA has the ability to catalyse the synthesis of its own nucleotides and moreover to replicate itself.[8] This *in vitro* selection of specific ribozyme activities is of such effectiveness that it has been used in the selection of deoxyribozymes. That is to say, the traditionally inert DNA molecule can also be compelled to perform a surprising variety of chemical reactions, such as RNA transesterification, DNA cleavage, DNA ligation, DNA phosphorylation and porphyrin methylation.[9]

The flow of information from RNA to proteins has also been a source of interesting surprises with respect to the central dogma. When the genetic code was solved in 60s, the attention was immediately drawn to the observation that this code was universal. All organisms in nature seemed to use the same language to store and transmit genetic information. In the course of the following years, it was discovered that several organisms fell outside this norm, particularly in their expression of the message contained in minute cytoplasmic organelles called mitochondria.

Additional findings substantially extending our perspective on the central dogma, relate to unexpected properties of some proteins. For example, certain proteins from bacteria and yeast have the capacity to remove internal fragments from themselves in an autocatalytic manner. The intervening polypeptide (intein) is precisely excised from the precursor protein and the flanking polypeptides (exteins) are ligated to form the mature protein.[10] The biological meaning of this splicing of proteins is still unknown, although most inteins harbor homing endonucleases which turn inteins into infectious elements by mediating horizontal transfer of the intein coding

[7] For a review, see Bartel, D.P. and Unrau, P.J., *Trends Biochem. Sci.* 9, M9-M13, 1999.

[8] Johnston, W.K. *et al*, *Science* 292, 1319-1325, 2001.

[9] Li, Y. and Breaker, R.R., *Curr. Op. Struct. Biol.* 9, 315-323, 1999; Breaker, R.R., *Science* 290, 2095-2096, 2000.

[10] Paulus, H., *Ann. Rev. Biochem.* 69, 447-496, 2000.

sequence. Prions are also a good example of a novel concept within the dogma. These protein agents, which affect the mammalian nervous system leading to diseases such as Creutzfeldt-Jakob, kuru and scrapie, can cause a non-physiological modification of other proteins seemingly without the need for genetic material.[11]

The Functional Genome

It is quite possible that if Gunther Stent had known that after the publication of his work there would appear exceptions to the universality of the genetic code, splicing and editing of the RNA, the reverse transcription of RNA, the splicing of proteins, the presence of catalytic DNA and RNA, etc., he may have abstained in 1968 of his prediction about 'the approaching decline of molecular biology'. And yet, it is highly likely that molecular biology has yet to reveal many of its greatest and surprising secrets, upon the unfolding of functional genomics. This novel field studies the organization of the genes, the mechanisms that control their expression and the interactions that are established among them to make up the physiology of an organism.

The fundamental discovery of Watson and Crick took center stage only one year after Martha Chase and Alfred Hershey, based on the observations of Oswald Avery, confirmed that DNA was the genetic material. Doubt no longer existed that this polymer was the structural key to the development and organization of living organisms. Then, it was assumed that a simple relationship between phenotype and genotype would allow an interpretation at the genetic level for every characteristic exhibited by living organisms. Possibly, this somewhat straightforward and ingenuous vision of the problem was influenced by the extreme reductionism championed by Francis Crick.

Later investigations, nevertheless, demonstrated that the genome is considerable more complex and that multiple factors influence phenotypes. An initial source of astonishment came from the observation that the amount of DNA contained within a genome and the place of organisms in the evolutionary scale do not follow a linear relationship. Thus, for example, many plants have more DNA than mammals, and still more surprising, the amoeba, a very small unicellular organism, has 200 times more DNA than *Homo sapiens*. This phenomenon is referred to as the *C*

[11] Prusiner, S.B., *Proc. Natl. Acad. Sci. USA*. 95, 13363-83, 1998.

value paradox. Although today we correlate this phenomenon with the fact that only a fraction of the genome has a coherent message (around a 1.3% in the man and a still smaller percentage in plants), the function of the non-coding DNA is for the most part unknown. For whatever reason, this portion of the genome must be essential, as its maintenance requires high energy consumption.

The Human Genome Project has brought new surprises that have come to defy the basis of genetic determinism, i.e. the traditionally sustained belief of the existence of simple causality between phenotype and genotype. As it is commonly known, this project anticipates reading (sequencing) of the genome in its totality, the elucidation of the genes encoded and their corresponding chromosomal locations (genetic map). The Human Genome Project also incorporates the study of genomes from other organisms, with the purpose of making comparative analyses among them.

Without a doubt, the most remarkable discovery that has been contributed by the Human Genome Project was not only the confirmation that there is no simple correspondence between the degree of morphologic complexity and DNA content, but neither is there a correlation between this physical property with the number of genes in the different organisms. Thus, one sees that solely within the group of the bacteria, the number of genes ranges from 473 (*Mycoplasma genitalum*) to nearly 8,000 (*Myxococcus xanthus*). Among them, the *Escherichia coli* bacterium, widely used in laboratory experiments, has a genome made up of about 4,500 genes. The yeast *Saccharomyces cereviciae*, also unicellular, possesses 6,034 genes. Since the latter is larger and possesses a more elaborate structure than bacteria, a greater difference in the number of genes had been expected. Among the metazoans (multicellular beings), the fruitfly *Drosophila melanogaster* appears with 13,061 genes, whereas the roundworm *Caenorabditis elegans*, that measures a millimeter in length and displays a more basic morphology, has 19,099 genes. Furthermore, *Arabidopsis thaliana*, a cress plant whose genetic simplicity makes it a useful model for laboratory studies, has a genome of 25,500 genes.

How many genes should be expected for the human species? Until a few years ago an estimate near 100,000 was postulated, although some experts elevated this number as far as 165,000. Then, in February of 2001, data published in Nature by the Human Genome Project consortium,[12] as well

[12] International Human Genome Sequencing Consortium, *Nature* 409, 860-921, 2001.

as that published in Science magazine by the biotech company Celera,[13] threw out an unexpectedly low number. The genome of the human species seems to have about 30,000 genes, little more than the cress *A. thaliana* and only 50% more than *C. elegans* worm. Other genomes whose study has not yet been concluded, such as those of the mouse and the chimpanzee, are expected to contain a gene number very similar to that of our own.

But it is not merely the low gene number that draws our attention. Something equally unexpected is that the genomes of the yeast, the fruitfly and the worm share 46, 61 and 43 percent similarity with the human genome. These observations raise fundamental questions. How is it that this low number of genes contains all the information required by a complex organism such as man? How do we explain that genomes sharing such a high degree of homology can give rise to such different organisms?

We do not have answers to these questions yet. The observation that more than a third of the human genes can undergo remodeling leading to the production of several functionally distinct proteins from each gene – a phenomenon called alternative splicing – does not appear to be a sufficient explanation. The DSCAM gene of the fruitfly *Drosophila*, which is involved in nervous system development, could theoretically give rise to 38,000 proteins by means of this alternative splicing. Therefore, it is clear that we must change our traditional vision of the genome and analyze its behavior like that of a complex system whose final product is superior to the mere sum of its parts. In other words, it is becoming more and more evident that although the number of genes are a determining factor in the phenotype of an organism, of equal importance are the inter-genetic interactions (epistasis), as well as the influence in gene expression exerted by the environment.

Thus, rather than saying that we have identified the gene for obesity, the gene responsible for cognitive abilities or the gene responsible for Alzheimer's disease, it would be more accurate to state that these genes are involved in the expression of these characteristics. In reality, the phenotype of each individual is dependent both on the properties of the genome as a whole and upon the interaction with the environment. This explains why the same mutation in a particular gene can give rise to dissimilar effects in different individuals, including failing to be expressed. Although this phenomenon is less frequent in characteristics arising from

[13] Venter, J.C. *et al, Science* 291, 1304-1351, 2001.

a single gene, it is certainly evident in the case of characteristics of multigenetic origin. A textbook example of this latter point is observed with the gene associated with increased risk of mammary and ovarian cancer, BRCA1. When both alleles of BRCA1, that is to say, when the genes derived from the father and the mother are mutated, the risk of contracting cancer is not greater than if only one allele is present. It is as a result of situations such as this one that geneticists have coined the concepts of penetrance and genetic expressivity, to mean, respectively, the proportion of individuals with a specific genotype that is manifested as a phenotype and the degree to which this expression occurs.

In relation to the previous example, it is possible to deduce that although certain risks can be affected by alterations in a single gene, it does not necessarily imply that altering the dose of this gene by means of genetic manipulation is necessarily going to harness the expression of this characteristic in beneficial and harmonic form. This is perhaps the most important challenge that faces gene therapy, the practice that was initiated over two decades ago as a promising alternative to alleviate the monogenetic diseases. To complicate matters still further, it has been known for some time that mutations of genes whose alteration simultaneously affects multiple functions does not always shed light on relationship among these functions. The existence of these genes, referred to as pleiotrophic, constitute further evidence as to why genome related studies must be approached in both a systematic and open-minded manner.

Research in microorganisms has demonstrated this apparent lack of direct correspondence between genotype and phenotype. Comparative analyses of genomes of microorganisms that live at high temperatures, have not explained the genetic bases of thermostability. Equally puzzling is the failure to elucidate the genes responsible for the remarkable resistance exhibited by the bacterium *Deinococcus radiodurans* to radiation. Recent investigations on minimal genomes using the knockout approach have brought to light unanticipated findings in this issue. This technology involves introducing mutations that disable a gene in order to examine the consequences on the viability of the organism. Observations in yeast, for example, show that of the 6,034 genes already mentioned only about 1,000 are essential for survival. It is assumed that functional redundancy occurs, in which similar genes (paralogues) can assume the tasks of the deleted ones. Statistical extrapolations of these works throw out a number of 300 genes which are absolutely essential to sustain life. In metazoans, knockout technology has also demonstrated some highly unexpected results, an

example being that the deletion of both oestrogen receptors still allows the birth of a healthy, although sterile, individual.

The concept of genomic plasticity had already been applied to the discipline of evolutionary genetics, accounting for the observation that certain morphologic characters remain unchanged in spite of a substantial genetic variability. These characteristics have been named canalized characters, since their manifestation stays within narrow limits in spite of stimuli having the potential to disturb them. A classic example is demonstrated by HOX gene clusters, which define the vertebrate body plan. All vertebrates, from sharks to man, have a similar body plan brought about by the presence of four HOX clusters. The bony fish have undergone a genome duplication of these gene clusters and now possess seven HOX clusters, yet still maintaining the same body plan. Further studies in this field have demonstrated that distant organisms in the evolutionary scale have very similar genes (orthologues) which possess completely different functions. One of the notable examples on the matter is the *otx* gene, which in the vertebrate lineage participates in head formation, whereas in the aquatic coelenterate Hydra this gene is associated with movement. In the same vein, genes that code for the eye crystal proteins have orthologues involved in responses to thermal shock and other stimuli that induce cellular stress.

Science has no end

The biologist Adam Wilkins, after examining the influence of Mendel, Darwin and Watson-Crick, suggested that in biology a Kuhnian style revolution which entails a new paradigm replacing a still effective one, has not occurred.[14] Strictly speaking, contends Wilkins, none of the seminal contributions of these prominent scientists constituted a new theory that substituted an existing one, as what really existed previously in each case was simply ignorance. In accordance with this, Richard Strohman maintains that a true revolution is currently taking place, where the existing traditional genetic determinism is being supplanted by a more systematic approach to genetics. The prevailing paradigm of the last several decades, reinforced by the reductionism of some leading scientists, found support in the statement: DNA to RNA to protein to phenotype. This axiom continues in its validity, declares Strohman, solely for those characteristics that are

[14] Wilkins, A.S., *BioEssays* 18, 695-696, 1996.

encoded by a single gene. But the vast majority of the cellular functions depend on the interaction of several genes, which are also influenced by the environment. It is for this very reason that it is easier to predict the appearance of a monogenetic disease (haemophilia, serious immunodeficiency, hypercholesterolemia) than those of a multifactorial origin (schizophrenia, Alzheimer's disease). According to Strohman, the new paradigm that is being heralded is that of epigenetics, the discipline that incorporates the study of mechanisms that impart spatial and temporal control of gene expression in the development from the zygote to the adult stage of complex organisms.[15,16] In this complex epigenetic network it is implied that once synthesized, proteins can establish a series of interactions using guidelines not originally encoded in the DNA. To phrase this another way, the network of interactions between the genes that is established by the proteins they encode, in conjunction with the influences of environmental factors on these interactions, constitute an epigenetic adaptive system that is complex and incompatible with the marked determinism that prevailed in the last century.

It will not be long before the views of Richard Strohman are verified. Either way, it seems clear that the application of a reductionistic logic in science can lead to false interpretations by limiting the confines of what remains to be explored. We must consider that biological systems are complex and experience demonstrates that as knowledge progresses new scenarios appear that could not have been foreseen with the previously available information. Scientific research always leads to new questions. For this reason, molecular biology, far from having found its limits proposed by Stent, is more vigorous than ever and most likely it is about to give birth to a new paradigm that will revolutionize the biological sciences.

[15] Strohman, R., *Bio/Technology* 12, 156-164, 1994.
[16] Strohman, R., *Nature Biotechnology* 15, 194-200, 1997.

DISCUSSION ON THE PAPER BY VICUÑA

CABIBBO: A great question is: will biology continue? Will physics continue? Who knows?

RAO: I think other than biology, there are a lot of other sciences, so let me say something. It's foolish of people to say that chemistry ended with the Dirac equation; Dirac himself said that, and that is unfortunate. And of course people say that Linus Pauling created modern chemistry when he put two dots and said there is a chemical bond.

CABIBBO: Nanotubes, etc.

RAO: The real point in chemistry is not based on this premise. The fundamental premise that explaining a chemical bond is not the end of chemistry. It's a wrong assumption: statements about the end of science, the end of the world, etc., are generally misplaced.

CABIBBO: I tend to agree.

RAO: This seems to be wrong in all these cases.

CABIBBO: I tend to agree. In fact probably even geography still has a lot of interesting aspects to be discovered.

VICUÑA: Well, at the begining of my talk I mentioned the book by Paul Horgan. He interviewed many scholars in different fields. Supposedly, all of them were more or less in favour of the end of science. But I heard this morning from the previous speaker, Dr. Shea, that many of the interviewees of Horgan in that book are not very pleased with the interpretation of their statements made by this journalist. But there have been prestigeous scientists in favour of the end of science. I didn't mention for example Leo

Kodanoff and the former President of the American Association for the Advancement of Science, Bentley Glass, who also said things such as 'experiments of increasing cost are designed to solve more and more irrelevant details'. As I said, he was President of AAAS. So, we have to be careful.

CABIBBO: Individual people may become tired of making experiments, but there'll be new people doing that.

THE UNIQUE AND GROWING INFLUENCE OF THE NEUROSCIENCES ON THE DEVELOPMENT OF OUR CULTURE

ROBERT J. WHITE

If we are to define and refine the cultural values of science in relation to human existence, we must continue to gain a greater understanding of the human mind and the brain. In the process, we must pause and once again ask ourselves the deep fundamental question: Who are we? In addressing this concept, we must take up the issue of: What are we? The classical Christian response to these questions is, of course, 'You are composed of body and soul and made in the image and likeness of God' in a Thomistic sense, primary matter and substantial form.

Perhaps, in an attempt to analyze this state we might begin with the physical body. Obviously, we can all describe the visual appearance of a person utilizing our senses but since we cannot physically observe the human soul the problem immediately arises as to where it is located, for example, within or outside the body or diffused throughout the substance of the entire soma.

What one would like to emphasize in the brief presentation above is that in the framework of our culture and its evolution and future to come, a single bodily entity, the human brain, has been totally responsible for all of the accomplishments of mankind since time immemorial. What we are saying is quite overwhelming for we are stating, categorically, that a living substance weighing no more than 3.5 pounds has discovered, constructed and learned all we know about the universe and ourselves. It is, then, the repository of all human knowledge gained to date and is completely responsible for all activities, be they good, bad or indifferent, of all generations in the past, the present and the future. Many medical scientists believe that

the body itself represents nothing more than a power pack whose primary responsibility is to keep the brain viable. The Central Nervous System's (CNS) other anatomical element, the spinal cord, is equipped with peripheral nerves as is the brain with its cranial nerves to conduct information to this organ and to convey instructions from it to all systems of the body. Thus, this cellular structure must provide for the assimilation and processing of all this information from these sensory sources that often arrives simultaneously requiring decision-making within milli-seconds.

One must apologize for this rather simplistic discussion of the human nervous system that enjoys such cellular and molecular complexity and architectural uniqueness. Think for a moment, of a musician playing the piano and singing an aria from some classical repertoire. Just try to imagine how many areas of both cerebral hemispheres must be involved to carry out this performance. In spite of all the research conducted on music, and the brain, we still have very little understanding as to how all of these functions fit so beautifully together. Yes, the human brain is the most complex, most incredible 'object' in the entire universe as we know it. Many would be inclined to argue these extraordinary properties that brain tissue provides are anchored to its biochemical and physiological base, but still more appropriately thought to be more 'correctly' identified with the mind.

Thus, is the mind just a sum of all the abilities and functions displayed by the physical structure – the brain? Or, is it a special form that inherits the brain but is not an organic part of it? All of these relationships are, obviously, important if not critical to our discussion of science and culture, for in the final analysis it is the mind/brain consortium that produces, amplifies, and modifies our culture in all of its dimensions.

What is being emphasized in this presentation is the simple axiom that whatever culture is, or becomes, in all of its elements, the human brain/mind is responsible. Thus, our appreciation of the universe in terms of space, time, and energy, is extremely limited and, in time, even our present concepts may be found to be totally incorrect. What is fascinating, is that in spite of all the scientific efforts of such men as Fr. George Coyne, with all their incredible telescopic equipment and computers, in the final analysis, they (the cosmologists), as human beings, must gather and interpret data defining what our universe really is. Once again, it is their brain/mind interface that will accomplish this awesome task.

When we examine the many factors that encompass our civilization and define our culture now, and in the future, the immediate issue arises: Who is responsible for its design and development? Obviously, we, the

world's population, are! It is imperative that we work to eliminate poverty and increase the level of education in the world. As a result, this critical responsibility and special attention must be focused on providing a scientific education for the youth of all nations. Within this educational effort, the discipline of neuroscience must be emphasized. Without the knowledge and understanding of the human brain/mind consortium, the advance of world culture and civilization could be severely compromised. As our human population moves into the future, the Earth could potentially become an inhospitable place with a severe shortage of resources such as lack of water, fuel, food and/or land for living. Thus, our evolving civilization and culture will be severely tested in the future requiring dramatic advances in many fields of science. Not only will this require important acquisitions of new knowledge, but the creation of technologies that presently do not exist if mankind is to survive well into the future. With birthrates in third world countries continuing to increase (although their overall populations are now being modified by the AIDS infection epidemic) and starvation, as well as the continuing overuse of the Earth's resources by the advanced countries, this will bring about serious limitations and will require major alterations in how we will live in the future. As a consequence, our civilization, and its associated culture, will demand overwhelming changes in all aspects of life to accommodate the evolutionary nature of our world as well as the universe. As has been emphasized over and over again, the necessary achievements required to sustain the viability of humanity are obviously through scientific advancement, which involves the intense participation of the human mind/brain.

While we have stated this crucial concept before, it is simply not easy to convince even the scientists themselves that this integrated relationship between the physical brain and mind must, in the final analysis, be at the very center of human existence as we know it. Everything we know, everything we do, results from this extraordinary relationship. While all scientific endeavors will continue to be essential to the formation of our culture in all of its dimensions, it remains for the discipline of neuroscientists to discover the origins of the 'bonding' of mind and brain and, in the process, be able to characterize the unique functions of this organ. Some would argue that in spite of outstanding research with subhuman primate models by Professor Singer, and others, our knowledge of the brain and mind is still severely limited and fragmentary at best. Such seemingly simple questions as: What is consciousness? What is memory? How and where is cognitive activity taking place? These are just a few of the fascinating capa-

bilities of the human brain/mind. Yes, this is the most intricate and foreboding entity in the entire universe. Within its cellular/fiber architecture, embedded in a watery gel, these absolutely unique properties exist and perform. Yes, it is in this miniature organic edifice that all these activities are taking place, often simultaneously. While many of these attributes of the human brain are thought to be unique unto themselves, the basic neurochemistry and physiology of the human brain appear to be essentially similar to what has been documented in the mammalian brain of lower animals. This is also true of the fundamental cellular structure and arrangement. However, the size and weight of man's brain favors the human. Also, the number of brain cells (neurons) and their connections (axons and dendrites) are markedly increased in the human brain represented by tissue impaction as seen on microscopic examination of CNS tissue histology. Thus, with this incredible biological mechanism man constructs and destructs our civilization and our culture.

Yes, this simple thesis dramatically demonstrates the importance of neuroscience, the scientific specialty charged with studying and explaining the human nervous system. In the process, we must charge it with the responsibility of not only discovering the loci of emotions, the regions for cognitive performance (including storage of intelligence and decision-making) and, of course, memory in all of its dimensions. This list of functions of cerebral tissue represents only a small number of activities that this organ is responsible for. One might ask at this point: Is there a cellular center for good and evil thinking, free will, love and hate, and sin? If such physical representations for these activities do not exist in the human brain, then, how do we appreciate and define beauty as supplied by a visual and auditory input? In other words, how and where do our cerebral hemispheres decide a piece of art, or music, in beautiful? There is literally no aspect of our culture (in which there is always an advancing and changing concept with multiple facets) that is not directly and totally produced and influenced by the human brain. Thus, it is obvious how important neuroscience, in the process of studying the brain, is to our developing culture.

Excitingly, there have been significant achievements in recent years in an attempt to explain these incredible functions of man's central nervous system. Much of this advancement is related to the introduction of highly sophisticated instruments that actually permit the neuroscientist to observe and collate information during directed activities in the human cerebrum.

These specialized imaging machines known as Positron Emission Tomography (PET) scans, and functional Magnetic Resonance Imaging

(fMRI) scans, generally provide recordings of changes in regional cerebral blood flow as well as measurements of localized metabolic activity utilizing radioactive labeled chemicals such as molecular O2 and glucose that are rapidly utilized by cerebral tissue during metabolic performance. While these instruments have extremely important functions in neuromedicine, they continue to represent one of the most critical advancements in neurotechnology for the investigation of the human brain in terms of locating the basic cellular areas responsible for various functions. For example, the location of such function such as movement, audiation and vision have been anatomically defined for at least a century. Now, with brain imaging studies the exact locations, often multiple, for these functions can be precisely documented in the cerebral cortex. In a clinical sense, brain imaging can now diagnose neurodegenerative conditions as well as malignant changes on the basis of their energy status. Evidence is also accumulating that psychiatric disorders such as schizophrenia and depression, even violent behavior, present with lower metabolic activity in certain areas of the brain. If you can identify a region in the human brain where there are metabolic alterations occurring, for example associated with violent behavior, then, with further refinements of this biotechnology, we will be able to find the anatomical areas in the brain in which the refinements of human performance (discussed previously) will be documented. Hopefully, as this neuroimaging technology carries forward, ancillary studies in cognitive psychology, neurophysiology, neurochemistry, and computer simulation will assist in understanding how the physical areas of this organ actually perform. Having this neuro-information available should, at long last, assist mankind in accepting how humanity structures the elements of our society, and how it forms and defines our culture bringing it literally into existence. All this knowledge of the brain carries an additional factor in terms of effecting our culture and civilization itself; which, in final analysis, could be a supremely crucial factor both in a positive and negative way. We are discussing here an entirely new field, that of neuroaugmentation. At present, this is best presented in two ways: First, the neuropharmacology effect on the neurochemical format of the brain that will result in subtle or even dramatic changes in cerebral performance. In time, significant improvements in memory, cognition and intelligence will be produced as a result of brain/mind functional chemical enhancements. Second, through the intervention of brain surgery. Obviously, the science of neuropharmacology has already provided hundreds of mood altering drugs but, in time, with further research the surgi-

cal-neurological area will become very important. Its beginning can be traced to the era of tissue ablative operations for pain and frontal lobotomies for intractable psychiatric disease. Now, we are rapidly reaching the time when surgery/electronic control of brain function will be possible.

Already such diseases as Parkinsonism have their neurological symptoms decrease through a stimulation procedure via precise stereotaxically placed electrode systems in the depth of the brain. There is growing evidence that with further design of this already sophisticated equipment, significant mental control of an individual would be possible. Thus, we must be prepared to harness the mega contributions from neuroscience research for the good of our evolving culture. At the same time, we must be extremely careful about permitting any chemical or surgical biotechnologies to alter the fundamental nature of man. Neuroscience, as all sciences, must continue to contribute to, as well as help shape, our culture, but always in a positive and moral way.

DISCUSSION ON THE PAPER BY WHITE

PAVAN: I do agree entirely with the value and purpose of the brain, but how does the brain operate in relation to culture? What are the mechanisms, the main mechanisms by which culture is made? Could I say that this is language, or are there other more important factors?

WHITE: Well, the difficulty is that in so many ways we have a great understanding of how the brain functions physically, but even with the superb presentation of Professor Singer today, I would say that much of what we attempt to understand is still very difficult. Although it may be true in the range of subhuman primates, when we ask how culture is developed and conceived, as I said in my paper, we know that the brain is the organ in which these tasks are performed, but how it works, how it assembles the facts, and how they may change or modify, I think that a great deal of that activity is still not appreciated. It can be appreciated, but just as we saw, we're talking about location, it doesn't tell us how we do it. For example, one thing we do not know is just exactly what happens if, for example, you want to raise your arm. Where does that command come from? Why was that done? Well, I think it's the same way when you are shaping, augmenting and changing what we call culture in all of its aspects: we don't know where it's done in the brain yet.

CABIBBO: Well, if I may say something as a physicist, it might be that the difference between a human and a chimpanzee is only a difference of quantity. There are many examples in physics where a small difference in quantity makes a fantastic difference in quality. Well, just to make one example, the atomic bomb, you need a certain critical mass. If you have less than that, you just have an inert piece of metal, if you have more it explodes. Another example is given by phase transitions: at a certain temperature there is agitation of atoms; if you heat water at 99 Celsius it is water, if it is at 100.0001 Celsius it becomes vapour. So, it's clear that there is a phase transition, that

there's a huge difference between man with his capacity for communication, for formal thought, for storing in a communal database, I mean, because it's true that the brain has notions of a science, but there is not a single brain which knows everything, each brain contains a little bit, it is a community of science and writing, etc., which makes a big difference, and it might be that at least certain people like you or like other scientists of the brain will tell us whether there is a qualitative difference between the human brain and other brains, I don't know, different organisations etc., but even if there is no such difference in organisation maybe a small, relatively small difference in quantity is what is needed to make this jump. You can see that animals are very close to communicating. People who have dogs or cats claim they communicate with their pets. Obviously the communication is very small. At a certain point you start a chain reaction and culture begins.

WHITE: A chain reaction, yes. But the simple thing, as I mentioned, is obviously that the size of the brain is in favour of man, and yet there are larger brains, some of the larger animals do have brains that weigh more, but it's the impaction, it's the number of neurons and the number of cells, connections, and synaptic relationships that again favour the human brain. The fascinating thing though, Professor, is that the same chemical reactions, the same histology, the appearance of the brain under the microscope, the same electrical phenomena that we see and we measure, there's nothing between these features in the human brain and what we would see in a Rhesus monkey's brain, and yet, as you point out, the difference between performance, understanding and accomplishment is overwhelming. Like Professor Singer, I've spent years working with monkeys, and I can tell you they are incredible creatures, but I haven't seen any of them build a St. Peter's yet! I went to a conference recently in America where they were trying to put together a group of lawyers who support legal rights for subhuman primates and remove them as properties under the law and they would become persons. One of the lawyers who were opposing this, stood up and said, 'Well, I don't see any of them here in the audience that are asking to have a lawyer.' But you are right: the similarities are absolutely fascinating. On the other hand, the brain is such an incredible organ, yet how can you arrest the circulation of the human brain for an hour at a very low temperature and have it be rewarmed and retain the same intellectual capabilities and personality? After all, we've stressed the fact that it doesn't have redundancy, which it does have, incidentally. It is just incredible; we have much to learn.

SCIENTIFIC CULTURE AND THE TEN STATEMENTS OF JOHN PAUL II *

ANTONINO ZICHICHI

Introduction

From the very earliest days of his Pontificate, Karol Woytila has maintained a particular relationship with Science and its values. Just a few days after his election, he opened the doors of the Church to Science, giving life to a continuing relationship with the international scientific community. This relationship has played an invaluable role in eradicating the danger of a Nuclear Holocaust, and in confronting, through factual projects, the danger of an Environmental Holocaust in the undeclared war between the planet's North (the rich) and South (the poor). No better guide exists for the scientific community in undertaking this task than the Pope's ten statements, which have given life to a Scientific Culture in communion, not in conflict, with Faith.

The role of this pastoral work of the Pope is analysed in the context of modern culture in which – up until the arrival of John Paul II – the dominant part of atheist culture had raged, using popularisation of so-called science as an effective weapon for achieving the transformation of streams of falsehood into truth itself. Mystification of culture in the 20th century became a powerful arm of the two atheist cultures, Nazism and Stalinism, which had the common goal of outlawing Faith as Science's number one enemy. These two fearful cultures were deliberately blind to the fact that Science was not born in atheism's home, but in the heart of our Christian

* Original in Italian. English translation by Mrs Susan Biggin, edited by Mrs Jean Engster-Montgomery and Eng. Claude Manoli.

culture, with Galileo Galilei, as an act of Faith in He who made the world, and that Science was (and is) a source of values that are in communion, and not conflict, with Faith. It is these values that have been given a new life with the Apostolate of John Paul II, whose ten statements sum up the values of Science and its role within the culture of our time.

There are three chapters here. The first covers the ten statements followed by a brief discussion. The second chapter is dedicated to the ninth statement, which has special significance for this Symposium. John Paul II in fact says that Science is born in the Immanent but brings man towards the Transcendent. We shall see if this is true. The third chapter examines the so-called popularisation of science and the issuing cultural falsehoods. The conclusion gives a summary.

1. The Ten Statements of John Paul II

1.1. *Error and Forgiveness – The First Statement*

On the 30th March 1979, His Holiness John Paul II met with physicists of Europe at the Vatican, to open the doors of the Church to Science, thereby allowing the Catholic Culture to take back home what in truth are its own treasures of the Galilean Scientific Culture. John Paul II says:

> Whatever is born of an act of Love must never be punished. If misunderstood, thus if it seems in error, this act of Love must be forgiven. Indeed, when understood, this act of Love will enrich our Faith.

This statement of John Paul II follows the teaching of Sant'Agostino on the preminent role of Love. In fact Sant'Agostino says: 'Love and do what you will'.[1] The relevance of 'Love' is of major significance for Galilean Science. At that time, no one understood that Science was born of an act of Faith and Love towards Creation. It escaped everyone, then, that, studying the material world, Galilei had uncovered the first footprints of the Creator of all things visible and invisible. And yet it was these traces that he said he wanted to seek, through an act of Faith in the Creator.

The Fundamental Laws of Nature enrich our Faith, but when they were discovered, they were confused with a detail that seemed offensive to the act of Faith: the fact that it is the Earth that moves, not the Sun. The three levels of scientific credibility had not yet been discovered, and it was there-

[1] 'Ama et fac quod vis' (*Epistolam Joannis ad Parthos*, tractatus 7, sect. 8).

fore difficult to understand how and why this apparent offence was linked to an act of Faith and Love towards Creation. This Act of Love enriched Faith, giving it, in the Immanent, the foundations of logical rigour that no one could have imagined possible, precisely because they were rooted in the material component of our very own existence.

Galilei studied stones in order to discover the Logic of Creation. He could have instead discovered chaos. Had Galilei not existed, we would know nothing about the existence of the Fundamental Laws of Nature. So two questions arise:

– what did Galilei know about the fact that the Fundamental Laws of Nature had to exist?

– and on what foundations was he able to conceive that these Laws had to be Universal and Immutable?

Imagining the existence of Universal and Immutable Fundamental Laws does not involve acts of Reason and nothing else, but of Faith in the Creator of the world.

Were it not for Galilean Science, we would not be able to say that Fundamental Laws of Nature, Universal and Immutable, exist; nor that these Laws lead to the unification of all the phenomena studied in the visible Universe, which appears to us with just four dimensions.

The Grand Unification brings with it the need for a Superworld, a scientific reality with forty-three dimensions: eleven of the 'boson' type and thirty-two of a 'fermion' nature.

We are beholding the most extraordinary conceptual synthesis of all time. And, we repeat, man has arrived at this magnificent synthesis through an act of Faith and Love towards Creation, born in the heart of our culture, an act of Faith that, in the first statement of John Paul II, receives its first and ultimate seal.

1.2. *Science and Faith – The Second Statement*

In 1979, John Paul II not only opened the doors of the Church to Science, but placed Science on the same pedestal as the values of Faith, saying: 'Science and Faith are both gifts of God'.

And indeed, Science studies the Fundamental Laws that govern the material structures of Creation. These laws could not exist if we were the children of chaos. These laws are the proof that in the Immanent there exists a rigorous Logic that is valid everywhere: from the heart of a proton to the edges of the Cosmos.

Among the innumerable forms of living matter, we are the only one that has been granted the gift of knowing how to decipher the footprints left in the Immanent by the Creator of all things visible and invisible.

It is this statement that led to a new alliance between John Paul II and the broadest scientific community ever brought together in the world – the WFS (World Federation of Scientists): ten thousand scientists from one hundred and fifteen nations, who, as we shall see, met with the Pope at the Erice Centre on the 8th May 1993.

1.3. *Science and Technology – The Third Statement*

We live in a culture that attributes to pure scientific research responsibilities that belong in their entirety to Technology (use of Science).

It is not the dominant atheist culture that came to the defence of Science against crimes it never committed (the arms race and irresponsible industrialisation), but John Paul II.

And the third statement of John Paul II is the proof:

> The use of Science is not anymore Science; this is why Technology could either be beneficial or harmful to life's values and human dignity.

A clear distinction must be maintained between Science and the use of Science (which is given the name Technology). The great scientific discoveries must be distinguished from technologies for warfare, from reckless industrialisation, from genetic manipulation.

To succeed in deciphering what is written on a page of the Book opened by Galilei has no connection whatsoever with the use that political and economic aggression can make of that discovery.

By placing Science on the same pedestal as the values of Faith, John Paul II gives Science the power to defend itself from attacks of the dominant atheist culture, separating quite clearly Science (the study of the Logic of Creation) and Technology (the use of Science, whether for good or for evil).

For the first time in the History of the so-called modern era, a clear distinction is made between Science and Technology. This separation confers an extraordinary cultural dignity on the great scientific discoveries, and allows them to be distinguished from technological applications, from the violence wrought on the environment, from thoughtless industrialisation, and from genetic manipulation used against life and against the very dignity of this form of living matter, called man, made in the image and likeness of the Creator.

1.4. *Dangers of Technology and Scientific Truth – The Fourth Statement*

In a message to the WFS, John Paul II says:

> Man could perish from the effects of technology that he himself develops, not from the truth that he discovers by means of scientific research.

This fourth statement of the Pope allows the great scientific discoveries to be distinguished from technology for warfare, from thoughtless industrialisation, from genetic manipulation. The effort made by John Paul II in defence of Science – as distinct from its use – has led a large percentage of the public finally to understand the radical difference that exists between Science and Technology. The declarations of the Holy Father have also encouraged scientists to speak out against the mystifications of the dominant atheist culture.

This statement of John Paul II allows us to understand that Science can be put to use for the common good, but that it can also be used for evil ends, and that the choice between good and evil is not scientific but ethical and cultural.

The Pope's earnest encouragement instilled in the scientific community of one hundred and fifteen countries the desire to create the International Committee 'Science for Peace', thereby bringing this community down from its ivory towers to get to work against the dominant culture and its mystifications, through the publication in 1982, of the Erice Statement.

Before the fall of the Berlin Wall, an awareness had arisen in our community of scientists of the need to leave the ivory towers, in order to let the wide public know about the profound difference that exists between 'scientific culture' and 'scientific popularisation'. Ten thousand scientists from one hundred and fifteen nations signed the Erice Statement, specifically since here, this time, the real and great Science was talking, in first person, without mediators. This document was drawn up by three people: Kapitza, Dirac[2] and the present author.

[2] A note about Kapitza and Dirac. Pëtr Kapitza was the only scientist in the USSR to have had the courage to say no to Stalin, who wanted him to direct the project for the most devastating bomb ever conceived: the one based on nuclear fusion. In the USA, the proposal of Oppenheimer was being discussed. He wanted to shut down the nuclear arms race. This proposal led to him being investigated, as if he knew about Stalin's decision. We would do well to remember that the great Kapitza (discoverer of superfluidity) was stripped of his title and reduced to living in hardship until the death of the greatest communist criminal in History. Dirac (father of the equation that opened up to Science the horizons of antimatter, never conceived by anyone before) worked on the project for the free world's first nuclear bomb, terrified that Hitler might arrive first.

1.5. *Missiles and the Heart of Man – The Fifth Statement*

To the scientists of Erice engaged in the study of how to overcome the danger of a Nuclear Holocaust in the horrific conflict between the two Superpowers (USA-USSR), John Paul II said:

> As in the time of spears and swords, so today, in the missile age, to kill, more than arms, is the heart of man.

This statement of John Paul II made a decisive contribution to the effort undertaken by the largest East-West-North-South scientific community that ever existed, to examine the foundations for a scientific-technological agreement between the two Superpowers, designed to avoid the danger of a Nuclear Holocaust issuing from the USA-USSR confrontation.

The joint effort of John Paul II and the scientists signatories of the Erice Statement made a crucial contribution to the fall of the Berlin Wall, upholding with concrete facts the validity of this Great Alliance between the scientists of Erice and John Paul II.

1.6. *Scientific Voluntariate – The Sixth Statement*

With the danger of the Nuclear Holocaust overcome, the Holy Father initiated another action within the great movement of scientists, engaged for a long time in studying the danger of the Nuclear Holocaust, saying in one of His messages to the WFS:

> Voluntary Science is one of the noblest expressions of love for one's fellow men.

The aim of this great plan was to study the Planetary Emergencies. In 1993 the Pope came to Erice to meet with the WFS scientists representing 115 Nations. The presence at Erice of John Paul II on the 8th May 1993 crowned a series of meetings and initiatives whose roots lie in the Papal *Magister*. For this extraordinary Pope has known how to open the doors of the Church to Science, without ideological, political, or racial distinction, and beyond any geographical barrier. In so doing, he has been able to give new drive to the culture of our time such that, after endless cultural mystification that threatened the very values of human dignity, great scientific discoveries have managed to penetrate the heart of the culture of our time – so-called modern, but in reality pre-Galilean and so very dispossessed of the truth.

The Earth belongs to everyone: rich and poor, believers and non-believers. A careful examination is needed of the vital features of this

satellite of the Sun, a study that leads to a use of Science with the aims of peace, progress, and the defence of Nature. Do this, says the Pope, putting into action another form – one of the most noble – of love for your fellow man: the Scientific Voluntariate.

And so it was that the international scientific community, encouraged by John Paul II, put into action the Scientific Voluntariate, carrying out in a global collaboration (East-West-North-South) fifty-five pilot projects whose results allowed the conclusion that it is possible – provided that there is the political will – to face and resolve the Planetary Emergencies in the new millennium, giving future generations the hope of a life of well-being and brotherhood, in communion with all people of the Earth.

It should not be forgotten that the Earth is threatened by the danger of an Environmental Holocaust in an undeclared and hidden war between rich (North) and poor (South). John Paul II urges the scientists of the WFS to commit themselves through the Scientific Voluntariate to a study of the state of health of this space shuttle on which we have been graced to have been born.

The third millennium has need of the fundamental values of our culture, which is based on Love, to create a new society where Brotherhood, Charity, Forgiveness and Friendship among people triumph. This statement of John Paul II forms the foundation stone on which the whole of Humanity, in a Great Alliance between Science and Faith, can build the Hope to defeat the danger of an Environmental Holocaust. The results obtained from the pilot projects are the only material proof that the scientific community has been able to give to the G8 governments to convince them of the fact that, if there is political will, it is possible to defeat the Planetary Emergencies.

1.7. *The Use of Science for the Good of Humanity – The Seventh Statement*

Were it not for political and economic violence, scientific discoveries would find one single route for application: that whose goal is to improve the quality of life and the defence of dignity for all creatures travelling on this satellite of the Sun.

Science would continue to progress in deciphering the Book of Nature, and neither the arms race nor irresponsible industrialisation would exist. In a world in which a culture of Love, Brotherhood and Solidarity triumphed, the use of Science would serve only good purposes,

and would correspond to a continuation of the Work of Creation. Indeed, the seventh statement of the Holy Father says:

> The use of Science for the good of humanity is a living testimony of an extraordinary continuity and a constant unity with the work of Creation.

The use of Science for the purpose of good has been the force behind the study and research that have led the world to carry out pilot projects for defeating the Planetary Emergencies. The seventh statement clearly shows that it is vital for the struggle against the Planetary Emergencies to take a firm place within modern culture.

1.8. *Love and Frontiers – The Eighth Statement*

In 1990, the Holy Father as a consequence of the meetings with the WFS scientists, made an appeal, while in Aversa, to convince all, scientists and non scientists, of the need to promote a Civilisation based on Love, saying:

> Love conquers all, demolishes frontiers, shatters the barriers between human beings. Love creates a new society.

1.9. *The Transcendent and the Immanent – The Ninth Statement*

The great appeal of our existence lies in the duality that characterises all we do, moment by moment, day by day, during the course of our lives. The two supporting columns of this duality are Science in the Immanent, and Faith in the Transcendent. In a message to the WFS, the Pope says:

> Science has its roots in the Immanent but leads man towards the Transcendent.

This statement by John Paul II has been taken up most enthusiastically by one illustrious member of the WFS – Professor Čerenkov – as indeed by the entire international scientific community. Chapter 2 gives a closer examination.

1.10. *The Great Alliance Between Faith and Reason – The Tenth Statement*

The tenth statement projects the necessary alliance for the culture of the third millennium into the future. John Paul II in fact says:

> The non-believers are thinkers; the believers are thinkers who pray; together, believers and non-believers act in good faith to implement the Great Alliance between Faith and Reason.

The future will be dominated by two factors. One is linked to our Transcendental Sphere, and is Faith. The other is part of our existence in the Immanent and makes increasing reference to the rigorous component of our thought and our activity, and is Reason.

Within the Great Alliance between Faith and Reason lies a strong source of hope, such that the world may see the defeat of those who show contempt for Faith or Reason. Although of Islamic faith, Professor Abdus Salam [3] loved the Pope. He was convinced that the world's future had to be built on a Great Alliance between Faith and Reason, and that Science should have been taught from the world's altars.

2. Let us See if it is True that 'Science Is Born in the Immanent but Brings Man Towards the Transcendent'

This chapter – as we have already noted – is dedicated to the ninth statement of the Holy Father, who says:

> Science has roots in the Immanent but brings man towards the Transcendent.

Let us see if this is true.

2.1. *Reason According to Believers and the Three Levels of Scientific Credibility*

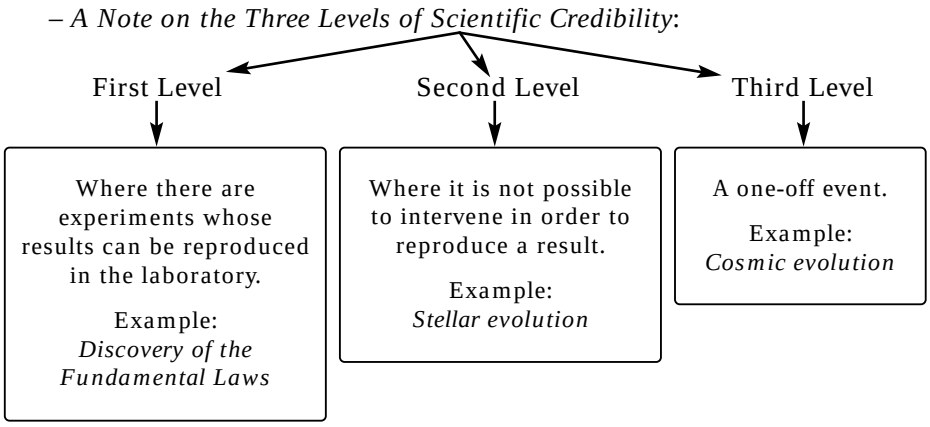
For believers, Reason is a God-given gift and has allowed us to discover:

– Language, from which collective and permanent memory is born, thanks to Writing.

– Rigorous Logic, which has given rise to the great constructions of Geometry, Arithmetic, Analysis, Algebra, Topology.

– Science (with its three levels), which allows the certainty that the world is not ruled by chaos but rather by a rigorous Logic with laws that are valid from the heart of a proton (a millionth of a billionth of a centimetre) to the fringes of the Universe (a million billion billion kilometres).

[3] A note about Professor Abdus Salam: Nobel Laureate for his exceptional contribution to the understanding of the electro-weak forces, he dedicated his life to the young Galilean talents of developing countries. He held John Paul II in the highest regard, and considered the tenth statement to be a contribution of fundamental value to the culture of our time.



All the levels should be formulated in a rigorous way, and there should be no contradiction among them. An example of the link between the three levels of scientific credibility: Cosmic Evolution must be formulated in a rigorously mathematical way, and must be based on the discoveries of the Fundamental Laws made at the first level.

No phenomena known in the Galilean sense (i.e. rigorously reproducible) exist that cannot be explained as a consequence of the Logic of Creation: this represents the greatest conquest of Reason in the Immanent.

This study, undertaken by Galilei just four centuries ago, leads us to conceive of the existence of a reality even more exciting than the one we are used to – a reality of extraordinary symmetry which we hinted at in Section 1.1, and to which the name Superworld has been given.

2.2. *Reason According to Atheists*

For the atheist culture, Reason is the outcome of Biological Evolution of the Human Species. The Biological Evolution of the Human Species (BEHS), however, lies below the third level of scientific credibility. It is far from being comparable with Cosmic Evolution inasmuch as BEHS lacks rigorous mathematical formulation and is not based on reproducible experiments at the first level. If BEHS were Science at the first level, then the equation of BEHS should exist that leads to the outcome of Reason. And that is not all. There are innumerable forms of living matter. None of these, however, has been able to discover Science, or rigorous Logic, or Collective Memory. BEHS is unable to explain how it is that we are the only form of living matter that has the faculty of Reason.

2.3. *Atheism is Self-Contradictory*

Atheism is a contradictory logical construction. In fact, it denies the existence of the Transcendent.

If everything finds expression within the Immanent alone, then what BEHS would have is true: Reason is born and dies in the Immanent Sphere of our existence.

Since the greatest conquests of Reason are (as we have said) Language, Logic and Science, then Mathematics (the rigorous form of Reason) should be able to demonstrate that God does not exist, and Science should be able to discover that God does not exist.

Mathematics has not demonstrated the Theorem of the Denial of God and Science has not discovered the scientific proof of the non-existence of God.

If everything finds expression within the Immanent alone, how is it possible that there is no Theorem of the Denial of God, nor the scientific discovery of the non-existence of God? Here is the contradictory nature of the logical construction of Atheism.

2.4. *The Transcendent Solves the Contradiction of Atheism*

In the Logical Structure of the Believer, there exists the Transcendental Sphere, and Reason is a gift of God.

God has given us this unique privilege that has allowed us the Three Great Conquests. Logical Mathematics is not able to demonstrate the Theorem of the Existence of God in that, if it could, God could be Mathematics alone. God instead is everything. The same is true for Science. If Science were to manage to discover God, then God would have to be just Science. But instead, God is everything. It is the task of philosophical thought to demonstrate that God exists through the Transcendental Sphere of our existence and its connections with the Immanent Sphere of everyday life.

2.5. *To Discover the Logic of Creation*

If Language were sufficient to discover Science, this would have been discovered at the dawn of civilisation. If rigorous Logic were sufficient to discover Science, this would have been discovered by the Greeks.

To discover Science, it is not sufficient to think and reflect (Language), or to resort to rigorous reasoning (Mathematical Logic). To discover Science (Logic of Creation), there is one single route: to present rigorously

formulated questions to the Creator. This requires an act of humility: recognition that the Creator is more intelligent than any of us – philosophers, thinkers, mathematicians, logicians, scientists. It is necessary to surrender ourselves before the intellectual Majesty of He who made the world.

It was Galilei who understood this. He it was who said that the footprints of the Creator were to be found in the stones (just as in the Stars). Galilei brought the Logic of the Stars into common matter (stones, string, wood), through an act of Faith and Love towards Creation.

In pre-Galilean thinking, for atheists and believers alike, matter could not be a depository of fundamental truth. The Fathers of the Church were the first to say that Nature is a Book written by God. Galilei had the privilege of understanding that the characters of that Book had by nature to be mathematical, and that it was not enough to reflect on the heavens and Stars.

All preceding cultures attributed to the heavens properties that lay above those of the stones. Galilei brought the Logic of Creation into stones and common matter, saying that our intellect has a power below that of the Creator. And thus it is necessary to bow before His intellectual Majesty and ask humbly how He has made the world. In other words, what rigorous Logic – of all possible logics – did He follow to make the world as it appears to our eyes and our intellect? The significance of a rigorous and reproducible experiment is precisely that intended and experienced by Galilei: to present in humility a question to the Creator.

2.6. *Ten Thousand Years Compared with Four Centuries*

This is how, in just four centuries, we have managed to decipher a good part of the Logic of the Creator. And we have managed to understand just how right was the humility of Galilei. In fact, from the dawn of civilisation right up to Galilei – in other words, for a good ten thousand years – all that man thought he had discovered about how the world was made, without ever carrying out an experiment, turned out to be wrong. Still today, Galilean teaching rules the logic of all the scientific laboratories in which the Fundamental Laws of Nature are studied.

Here is a last example of enormous interest today. No one can tell us if the Superworld exists or not. And yet this theoretical reality has been placed on rigorous and mathematical foundations. It is on these foundations that we believe we have understood so many properties of the world in which we live. But even so, the Galilean proof to be certain of the existence of the Superworld is lacking.

Logical rigour is not sufficient; Galilean proof is needed, in that this is the reply the Creator gives to our questions. To know more about the Logic of Creation, as always, it is necessary to present the right questions to He who made the world. This is how, in just four centuries, we have reached the threshold of the Superworld.

2.7. *From the Immanent to the Transcendent*

Science has the goal of understanding what God has written, using the rigour of Mathematics. Galilei said and thought that the Fundamental Laws of Nature are in fact expressed as precise mathematical equations. What did the father of Science know, how did his studies of oscillating pendulums or stones rolling down an inclined plane allow him to deduce that rigorous laws had to emerge? Chaos, randomness, whim might just as possibly have appeared instead: one day like this, a year later quite different. One law for Pisa, another for the Moon.

Galilei instead was thinking in terms of fundamental and universal laws, expressible in rigorously mathematical form. Together, these laws were to represent, and *de facto* do represent, the Logic of Creation.

'In that stone there is the hand of the Lord. By studying *common objects* I will discover the Laws of He who has made the world'. This was the Faith that inspired Galilei to challenge the dominant culture of his time. He simply wanted to read the Book of Nature, written by the Creator in mathematical characters.

The Book of Nature reveals to us how the world has been made: the work of Creation. This opus could have been written in no other way but rigorously, in mathematical characters. It is the scientist, in the first person, who has to strive in order that everyone should know how to read that astonishing and fascinating Book.

In it is written how the world is made. Since it is dealing with a construction, its language has to be rigorous. Knowing how to read it means making available for the benefit of man the laws that rule the Cosmos, in communion, not in antithesis, with the word of God, that is, the Bible. The Bible is written in a simple way, so that everyone can understand it; its purpose is not to explain how the Immanent part of our existence is made. Instead, it has the goal of tracing out for man the path that leads to the Lord. Science gives us the certainty of not being children of Chaos, but of a rigorous Logic. Who is the Author of this Logic? Atheism replies: no one. This is why Science, born in the Immanent, brings man towards the Transcendent, because it is absurd that a rigorous Logic does not have an Author.

2.8. *'The Light of the World'*

The twentieth century will go down in History as the era in which the use of Science (Technology) was at the service of political violence. This era led to the tragic dark periods of Nazism and Stalinism.

Professor Pëtr Kapitza, discoverer of superfluidity and expelled from university, reduced to living – as noted in Section 1.4 – without income until the death of Stalin for having refused to manage the Soviet H bomb project, defined John Paul II as being the:

> Light of the World set alight to dispel the tragic shadows of Nazism and Stalinism.

2.9. *The Berlin Wall was to Fall in the Fourth Millennium. Instead ...*

During the seventies, various meetings were held at Erice behind closed doors, to reflect on the danger of an East-West Nuclear Holocaust. Participants in the meetings included a number of twentieth-century giants of Galilean Science. These included Paul Dirac, Eugene Wigner, Pëtr Kapitza, Edward Teller, Isidor Rabi, Victor Weisskopf, Richard Feynman and Robert Wilson. As we have mentioned before, Kapitza had had the courage to say no to Stalin, who wanted him as director of the Soviet H bomb project. This refusal had cost him expulsion from all university and scientific duties, with consequences that can easily be imagined. Kapitza fell from being a prominent member of academia (discoverer of superfluidity) to maintenance technician of electrical equipment until the death of Stalin. Along with Wigner and Teller, Dirac had participated in the Manhattan Project, refusing any payment. Teller and Wigner were the fathers of the American H bomb project.

The conclusion of these meetings was: conflict is to be avoided at all costs. However, sooner or later, unfortunately, something will happen.

Kapitza feared the arrival of someone crazy and irresponsible at the head of the USSR.

Had this happened, the first shot would have been fired by the USSR. And in a nuclear exchange, first shot means certain victory. Unfortunately – even without an irresponsible leader in the USSR – there was always the potential weakness, typical of a free and democratic system, to contend with.

If in the USA – through normal democratic process – a weak president had been elected, the USSR head, while in no way an irresponsible criminal but a politician educated on Leninism and Stalinism, might

have decided to grasp the opportunity with both hands. And to fire – on the basis of some pretext devised for the purpose – the first shot. But only a country whose governmental structure lacked the check of public opinion – and no other – could take advantage of the temporary weakness of the political adversary. The USSR held a potential for warfare twice that of the USA.

Conclusion: the USSR would have taken over Europe. And we would have had many centuries of 'real socialism'. The United States of America would never have envisaged a war to free Europe. They would have accepted the *modus vivendi*, just as they had accepted the surrender of eastern Europe to Soviet Imperialism.

The prediction, in the closed-door discussions of these scientific summits, was that our culture would have been reborn – not as a result of liberation by the USA – but rather as a consequence of the slow shift, very slow but inexorable, of 'real socialism' towards democracy and freedom. Estimated timescale: several centuries, perhaps a thousand years.

No one had predicted the arrival of John Paul II and that the Berlin Wall would fall.

This Pope brought about a rebirth of our culture with its values and conquests before the beginning of the third millennium. In this rebirth, right at the front, lies Galilean Science. The closed-door discussions held at Erice over the course of many years have convinced me of the importance of a totally unexpected and unforeseeable fact. A fact that in the history books of future millennia will be described as a miraculous event: the totally unpredicted irruption of this Pope into the History of the world. The Berlin Wall fell in the second millennium, not the fourth.

3. So-Called Scientific Popularisation and the Most Serious of All Cultural Lies: Science and Faith are Enemies

Atheist culture has used so-called *popularisation of science* to endorse so much cultural untruth. It has never spoken of Galilean truth nor has it ever talked about how Science came into being. Instead, through its propaganda campaigns, it has spread the most serious of cultural falsehoods, which would have 'Science and Faith as enemies'. And the pillar underlying this lie would have us believe that Science cannot be a source of values.

3.1. *The Values of Science and Faith are Closely Linked*

We will now see, instead, that Science is a source of values, and that these values are in perfect harmony with the values of Faith, not in antithesis. Below is a short summary of the values that Science has in common with Faith.

Revolution

We begin with the concept of revolution. When a scientific discovery arises, the dominant culture loves to point out that a real revolution has taken place.

The scientific revolution has never produced deaths or injuries. The concept of 'revolution' derives from the discovery that it was the Earth and the other satellites of the Sun that move, going around in their orbits. It was the 'revolution of the orbits' that gave life to Galilean Science. The term 'revolution' intended to emphasise the impact of the 'revolution of the orbits' of the planets on the history of the world. With the passage of time, cultural mystification is at work such that the scientific term 'revolution of the orbits' comes to take on the meaning of 'socio-political revolution' like the October Revolution that led to the first example of a Republic with Atheism as State religion, causing many millions of victims.

Instead, following a scientific revolution, everyone is richer than before. It would be more correct to speak of construction, rather than revolution. In Science, there is never denial of the past: it is improved, taken on board and built on. It is as if, when climbing an immense mountain, what we took to be the summit opens up a panorama never before observed – and, as if this were not enough, with it comes the discovery that there is another, even higher, peak.

The term scientific *revolution* does not in any way justify social revolution. But this is what the dominant atheist culture indeed did, in order to persuade that, after all, scientific rigour had necessarily to go down the road of *revolution*, understood in the commonly accepted sense of revolt, with attendant massacres and horrors of every type.

Racism

A scientist cannot say:

> I am unable to believe in this new scientific discovery because it was made by a man whose skin has a different colour from mine.

Science is an intellectual activity that rejects racism outright.

Universality

Man has always been in search of universal values. Science shows that Universal Laws exist. The Weak Forces that produce measurable phenomena in our laboratories are the same as those that make the Sun work. The light produced by a match is analogous to that produced by the Stars. The Gravitational Force, which makes a stone fall downwards and that holds us to the Earth is the same Force that oversees the formation of our Solar System and of the Galaxies.

Elevation of the Individual

Science exalts the individual and his work. The value of a scientist is not established by the power of the military tank, but by his intellect and research labours.

And here the entire sum of contribution must be recognised. Albert Einstein is inconceivable without Max Planck, James Maxwell, Isaac Newton and Galileo Galilei. All scientists, giants of Science: all believers.

Intellectual Stimulus

Science spurs man on to reach out for further conquests. There is no rest in our endeavour to extend and improve our knowledge. Instead, an ideology is put forward as if it were the final goal of an intellectual conquest. And this holds man back, century after century, on frontiers created from abstract speculations, which in no time at all become dogma.

Science accepts the dogma of the Transcendent. But it rejects dogma of the Immanent.

Humility

The scientist in his daily work faces problems he is unable to resolve. Galilei took more than a decade to understand friction and thereby arrive at the formulation of the first law of motion. Einstein dedicated eleven years, from 1905 to 1916, to get to the bottom of the significance of Galilei's experiments of the fall of material bodies. Eleven years, to manage to succeed in writing one equation. Science is made up of unresolved problems. Something happens, and we move on to the next thing. And there our difficulties begin again. Einstein worked for the last thirty years

of his life in an attempt at unification of all the Forces of Nature. It was the great, *unfinished* opus. How can a man who is unable to reply to a question be arrogant? Science, as we have said before, is made up of unresolved questions. This is why it is based on a pillar of intellectual humility. Arrogance is born of ignorance.

Truth

Should a scientist tell a lie, he would be excluded from the scientific context. For Science, something that is true has to be reproducible. The scientist, when he comes to understand something or make a discovery, has to explain in full detail how he has arrived at that result. Whoever, no matter what the colour of his skin, and wherever, and at any given moment, he has to be able to reproduce that scientific truth. Mystification and falsehood lie outside scientific activity.

Reflection on Facts

Science teaches us to reflect, to not rush to conclusions without checking every consequence of a discovery in the known sectors of the fundamental structures of Creation. Science trains us for objective, not emotive, judgement. It relies on facts, experimental proof that is reproducible, the baptism of Galilean scientific legitimacy. It does not rely on words and abstract formulae. Nor does it make sense to say that a theory is mathematically beautiful or ugly. It can be only true or false, although it also happens, almost always, that when a piece of research reaches its conclusion, when in a specific field everything has finally been understood, then the mathematical formulation turns out to be more elegant than anticipated.

Goodness and Tolerance

Science teaches intellectual goodness and tolerance. Extremes have to be understood, not defeated. Things that appear to be poles apart can both turn out to be necessary for a description of the fundamental phenomena of Nature. Just one example should suffice: the wave and particle property. Light, for a long time, was considered to be a particle phenomenon. Then wave-like. And the two descriptions seemed to be mutually exclusive. Instead, light is at one and the same time both wave and

particle. Many centuries have been needed to come to this understanding. The wave-particle *duality* is valid not only for light, but for all particles. This duality is one of the most significant conquests in the history of scientific thought.

Fight Against Preconceptions

Science fights an unceasing battle against preconceptions: even if centuries are needed to dismantle them. The great difference between Classical Physics and Modern Physics lies in the fact that a tiny quantity (the so-called *Planck's Constant*) was considered to be exactly zero. Another enormous quantity (the speed of light) was considered infinite. Three hundred years to break down two preconceptions.

Generosity

Science also has important facets of generosity. To explain to others the results of a discovery is something that enriches both scientist and listener. Science teaches that there exists a form, absolutely perfect, of generosity and love for our neighbour. He who gives up a piece of bread carries out an action of good, but clearly suffers if he has little bread. He who gives away what he knows, loses nothing, even if he ends up giving away everything he has.

Freedom of Thought

Freedom of thought is of vital importance for Science. This includes respect for that form of living matter known as man, and therefore respect for his dignity. Of all the forms of living matter, we in fact are the only one which has been granted the privilege of understanding the Logic He followed in creating the reality in which we live and of which we are made. This unique privilege is the source of the highest dignity to which one can aspire: that of being made in the image and likeness of the Creator of all things visible and invisible. To read the Book of Nature, written by the Creator, one needs to be free of any prejudice. The only guide being the replies given by He who has made the world when we put forward a question. The intellectual freedom to put a question to He who has made the world has to be absolute.

3.2. *If We Were to Live in the Era of Science*

If we lived in the era of Science, these values would form an integral part of so-called modern culture. In fact, they are truths that render Science an intellectual activity that is in perfect communion with religious thought. We are dealing with two essential components that make up our existence: one that operates within the Immanent, Science; the other that operates within the Transcendent, Faith.

And this is the conclusion one comes to. Science, by studying the Immanent in the most rigorous way that human intellect has ever been able to conceive, discovers a series of truths, whose values are in perfect harmony with those that the same form of living matter, called *man*, learns from the Revealed Truth.

Four centuries after the time of Galilei, that which the father of Science was able to see with a pure act of Faith and Love towards Creation becomes visible in dazzling clarity: Nature and the Bible are both works by the same Author.

The Bible – said Galilei – is the word of God. Nature instead is His writing.

If we lived in the era of Science, these truths would be the cultural heritage of everyone.

3.3. *The Other Cultural Mystifications of 'Scientific' Popularisation*

Scientific Culture has the duty to correct the cultural mystifications of popularisation of science, mystifications that might at first sight seem mistakes committed in good faith. But the fact that they are all bound to a common cultural substrate confirms that they are not. In fact, the mystification that Faith and Science are in antithesis is not the only instance where falsehood is elevated to truth by popularisation of science. There are many more. Here are a few examples.

Popularisation of Science has:

- *confused* Science with Technology.
- *never explained* that the three great conquests of Reason are: Language, Logic and Science.
- *always kept silent* regarding the Galilean distinction of the *three levels* of scientific credibility.
- *attributed to Science the responsibilities of the Planetary Emergencies*; these responsibilities belong to political violence

(planet packed with chemical, bacteriological and nuclear bombs) and economic violence (irresponsible industrialisation).

– *elected itself spokesman* of ideas (for example: scientific materialism) that are in total contradiction with the conquests of scientific thought.

– *endorsed* as frontiers of true and great Science research activities that still lie below the third level of scientific credibility (for example: BEHS, biological evolution of the human species).

Our epoch will go down in History as that in which *cultural mystification* has raged: *falsehood becomes truth*.

The main author of this *mystification* has been the *dominant culture*, first Marxist then leftist.

In this way, Science and Technology have been deliberately confused. And blame continues to be laid at the feet of Science, blame that instead belongs to political violence. Violence which, in the twentieth century, had examples of terrifying power in Hitler and Stalin, who exploited the use of Science (Technology) for political ends, not for progress or civilisation.

3.4. *If Everything is Science, Nothing is Science*

'Scientific Culture' is the only form of defence against cultural pollution, maintained Dirac, Kapitza and Fermi. If everything is Science then nothing is Science. And it is impossible to explain that scientific Marxism is the exact opposite of Science. It is thus necessary to distinguish Science from the other conquests of Reason – i.e., from Mathematical Logic and Language.

The umbrella of Language covers Poetry, Art, Philosophy and all intellectual activity that is not concerned with reading the Book of Nature in order to decipher the Logic followed by He who has made the world. Using Language, in all its forms, everything can be said and its contrary. Language – as Borges says – has the supreme aspiration of 'magnificent' structures such as a Poem can have, leaving aside Logic and Science, which is the Logic of the Creation.

Scientific knowledge is engaged full time in studying – in a Galilean reproducible way – this Logic. The key to distinguishing this activity from all others lies in intellectual humility, without which scientific knowledge would never have been born nor able to grow. This intellectual humility, which is vital for scientific knowledge, is not always present – in fact,

often quite the reverse – in intellectual activities that contribute to the growth of non-scientific knowledge. This is why there is only one Science, while there are many forms of Art, Literature and Philosophy and other intellectual activities, often in contradiction one with another. This has been the case in the past and will continue to be so in the future. Even so, it is philosophical thought that produces fundamental contributions in the study of the Transcendental Sphere of our existence.

The contradiction intrinsic in Language's very structure is surmounted when Philosophy comes into play: its roots allow an understanding of how and why this contradiction does not have to extend beyond the conquests of Language.

In other words, the fact that there are various forms of Poetry, Art, Music cannot be taken as a basis on which to build a humanistic culture in contrast with Scientific Culture. The contradiction lies in the Creativity of Language itself, from which arise various expressions of our way of hearing and seeing the world. It is right that it is so. It is required by Language's very structure. It is here that the links with the Transcendental Sphere of our existence come into being, links that extend to Logic and Science through the creative processes of these great conquests of Reason in the Immanent. Creativity in Language finds its maximum structure in philosophical thought, without which it would not be possible to reflect on the Transcendental Sphere of our life. It is at this frontier that Philosophy expresses the highest creative power.

Creativity in Science has to coincide with the Logic chosen by He who has made the world to create the reality we are made of and in which we live. We scientists are not able to invent the existence of the third lepton. We can imagine its existence on the basis of experimental results, which can suggest new avenues for us to follow.

But whether the third lepton exists is known to the Creator, before any scientist in the world. It is He who has decided to include this 'third column' in the structure of Creation.

We have been granted the privilege of discovering that it does indeed exist.

With Mathematical Logic, the significance of Creativity is different. It is a legitimate act of the intellect to invent a new mathematical structure: with its rules and theorems. This structure does not necessarily have its correspondence in the Logic of Creation.

In order for this mathematical-logical structure to exist, the only condition is the principle of non-contradiction. But the principle of non-contradiction arises in philosophical thought, an integral part of Language. Logic

formulates this principle rigorously, and uses it to underpin any of its structures. A structure – completely invented by the intellect – must not lead to a theorem and the negation of the theorem itself.

Having said this, the problem of the role of Mathematics in the Logic of the Creation remains open: this topic has impassioned the very best mathematicians of all time. There is no doubt that a formidable logical-mathematical structure can exist (and therefore be non-contradictory), without there being any correspondence with the reality of the world in which we live and of which we are made.

This in no way diminishes the fascination of the Creativity in the two conquests of Reason (Language and Logic), which, as distinct from Science, do not fall under Galilean-type experimental confirmation.

However, it is of fundamental importance to distinguish Science from the other two conquests of the Reason of the Immanent, in that, if everything is Science, then nothing is Science, with all the devastating cultural consequences, some of which are referred to in this Section.

3.5. *Cultural Pollution*

Kapitza said:

> Cultural pollution is the most difficult Planetary Emergency to overcome.

Here is an example. In the USSR, very few knew of the ecological disasters caused by the triumphs of the 'five-year plans' made known everywhere through propaganda campaigns, even in the western world, where they were taken as models of unprecedented development. In Italy, Communist Party members made great reference to them. No one, however, spoke of the ecological disasters of *Semipalatinsk* (100 times worse than Chernobyl), the 'Aral Sea' (50% of its waters destroyed), the 'City of Sulphur' (an area as large as half of Piedmont, contaminated to the point where the population had to go around wearing gas masks). These were the times of the cold war and no one dared to hope for a collapse of the USSR. But even so, the hero of Science, Pëtr Kapitza, considered it necessary to start immediately to fight cultural pollution in countries that were free; in those dominated by the USSR it was unthinkable. Dirac said:

> It is easy to declare ourselves as free men where there is democracy and freedom. Try doing this where political violence rages. Kapitza understood the consequences.

Cultural pollution has its roots in political and economic violence,

which, by dominating the media (TV, radio, press and other channels), has enabled so many flagrant cultural mystifications to become 'truth'.

A terribly effective arm of cultural pollution is pseudo-scientific confusion, an essential component of popularisation. To cite meaningless data as if they were Galilean proofs of scientific truth; to introduce apparently valid arguments with bibliographic references that add nothing to the inexistent proof of the point in question: this is the technique of cultural pollution that siphons off valuable energy from the struggle for the triumph of Scientific Culture.

3.6. *Science, Art and Mysticism*

According to a number of scholars, the pillars supporting our existence are: 'Science' (rational approach), 'Art' (aesthetic approach) and 'Mysticism' (religious approach). These theories have nothing new to say about the conquests of Reason. Rather, they go backwards in time because they ignore Galilean teaching. In fact, they confuse the Transcendental Sphere of our existence (to which Mysticism belongs) with the Immanent Sphere (to which Science belongs). Furthermore, they include in the so-called 'rational approach' both Science and Mathematics, confusing Science with Logic. Galilei teaches that, to discover Science, the rigour of Mathematical Logic (thus, the rational approach) is not sufficient.

If it were so, the Logic of Creation would have been discovered by the Greeks, two thousand years before Galilei. If mathematical rigour sufficed, we could say that the Superworld existed. The Galilean thesis is based on 'Language', 'Logic' and 'Science' and it could not be more rigorous in distinguishing the three conquests of Reason. Art in fact belongs to Language.

Summary and Conclusions

The ten statements of John Paul II have given life to a Scientific Culture that lies in communion, and not conflict, with Faith. In the 1980s, this Culture strove to make a real contribution to overcoming the risk of a Nuclear Holocaust. Then, with the fall of the Berlin Wall came the need to avoid the danger of an Environmental Holocaust created by the political and economic violence that fired the undeclared War between the planet's North (the rich) and South (the poor). Once again, Scientific Culture in communion with Faith took action to avoid the latent danger of an Environmental Holocaust, by implementing pilot projects related to the Planetary Emergencies, through the scientific voluntariate of its community.

Atheist Culture, using as its arm public dissemination of what is passed off as Science, has instead wanted all to believe that Science and Faith are enemies. It has always confused Science with Technology, has never explained that the three towering conquests of Reason are: Language, Logic and Science, never mentioned the Galilean distinction between the three levels of scientific credibility, and has laid at Science's feet the responsibility for the Planetary Emergencies – responsibility that instead belongs to political violence (planet packed with chemical, bacteriological and nuclear bombs) and economic intemperance (unaccountable industrialisation). Atheist Culture too has acted as spokesman of ideas, such as scientific materialism, that lie in utter contradiction with the conquests of scientific thought, and has endorsed as frontiers of real and true Science, research activities that still lie below the third level of scientific credibility (for example: biological evolution of the human species: BEHS).

Had Atheist Culture itself discovered Science, then the ten statements of John Paul II would never have been conceived. These represent the cultural guide to the concrete deeds of which the Holy Father has been author, right from the very first days of his Pontificate. And it is this guide that has made possible the birth of a Scientific Culture in communion, not antithesis, with Faith. The influence of the Great Alliance with Science and its values has enabled the danger of the Nuclear Holocaust to be overthrown (Erice Statement), and allowed the creation of scientific and technological foundations from which to confront issues of the Environmental Holocaust (pilot projects for the Planetary Emergencies).

The 20th century will take its place in History for having seen the fall of the Berlin Wall and the start of an undeclared War between North (the rich) and South (the poor). The third millennium has need of a Scientific Culture that is the fruit of the Great Alliance between the two most important conquests of Reason, which are Science, in the Immanent of our existence, and the God-given gift connected with Reason in the Transcendent of our being, Faith. We would do well to recall that St. Paul and all our theological tradition define Faith as a gift from God. A gift linked to Reason, as described by St. Thomas of Aquinas:

> Naturalis ratio per creaturas in Dei cognitionem ascendit, fidei vero cognitio a Deo in nos e converso divina revelatione descendit.[4]

[4] 'Natural reason ascends to a knowledge of God through creatures and, conversely, the knowledge of faith descends from God to us by divine revelation' (ScG IV 1, 3349).

While emphasising the rational aspect of Faith, the entire Christian biblical tradition attributes it to the inner touch by the Spirit of God (*instinctus Dei invitantis* by St. Thomas of Aquinas) that awakens the dynamism of freewill. Faith is thus considered by Christian theology as a gift from God within man's Reason, which under the impulse of this same freewill, and aided by the Holy Spirit, accepts the gift.

We are the only form of living matter that has been granted the privilege of the gift of Reason and freewill. Let us seek to use it well. The third millennium must open up man's heart to hope through a Scientific Culture in synergy with Faith, not in antithesis. This is why, as this remarkable Pope teaches, Science must do all in its power to ensure the triumph of the values of the Galilean Scientific Culture.

ADDENDUM

ELEMENTS OF SCIENTIFIC RIGOR IN THE THEORY OF EVOLUTION

1. *Premise*

During this Conference the problem of 'evolution' was discussed. My paper (*Scientific Culture and the Ten Statements of John Paul II*) was not intended to deal with this problem. On various occasions, I have made remarks on the need for a 'rigorous' attempt to describe 'evolution', especially as it regards the Human Species. This paper is a coherent synthesis of my attempt to encourage our colleagues in the biological Sciences to introduce the Galilean rules in their research work concerning evolution.

2. *More About the Three Levels of Scientific Credibility*

The scope of this work is to lay out a rigorous, Galilean-type scientific foundation for the Biological Evolutionism of the Human Species. As mentioned in my paper, Galilei teaches that three levels of scientific credibility exist. Let me elaborate on the three levels, since the understanding of these levels is closely related to the scientific rigor that is needed in the description of the Biological Evolutionism of the Human Species.

The first is that which entails: (1) mathematical rigor as a fundamental referent in the formulation of a problem, (2) the invention of an instrument capable of carrying out the key experiment for giving an answer to the problem, and (3) the reproducibility of the result obtained. The reproducible result is one of the foundation blocks of Galilean Science. It is obvious that the result also must be expressed in mathematically rigorous terms, and it is this that permits the elaboration of a theory able to describe not only the reproducible result that is obtained thanks to the invention of the original instrument, but also to point out further experiments to be conducted with new instruments in order to put the new theoretical formulation to the scrutiny of further experimental tests. An example of present day frontier of Physics: the Superworld. We think that a description of the phenomena known so far requires a Space-Time with 43 dimensions: 11 boson-

ic and 32 fermionic. The elaboration of the mathematical structure that describes this reality has arrived at the conclusion that new particles must exist; we have dedicated the last decade to the search for these particles without being able to obtain any reproducible experimental proof.

The Superworld theory is an example in which there is mathematical rigor in the formulation of the problem but there is no reproducible experimental proof. Therefore it could be that the Superworld theory is not part of the Logic of Nature. This is what the years to come will tell. The Superworld is an example of first-level Galilean Science to the extent that the experimental tests are susceptible to direct control: in case of doubt it is possible to intervene by repeating the experiments and by inventing new instruments that allow us to overcome doubts that may arise in the course of data analysis for a particular experiment. An experiment that we are able to keep totally under control, here on Earth.

The *second level* of scientific credibility is that in which it is not possible to keep the experimental test under control. There is mathematical rigor in the formulation of the problem and there is the invention of new instruments for observing the effects searched for, but there is no direct intervention. An example: the theory of stellar evolution. In one part of the sky, we observe the birth of a Star. In another part, the shining of a Star born for some time. In yet another part, the death of a Star. Different observations of many Stars being born, of others that are living and still others that are collapsing, allow the elaboration of a theory of stellar evolution. There is mathematical rigor. Reproducibility is guaranteed by the observation of different examples of Stars as they are being born, during their lifetime and as they are dying. What is missing, however, is the possibility of direct intervention. In cases of doubt we cannot turn off or turn on a Star. We cannot change the characteristics of a particular star in order to scrutinize, through experimental tests, a finding that could be born from the theory of stellar evolution's mathematical elaboration itself. This theory is strongly linked to the first-level Galilean Science. Example: in the theory of stellar evolution no astrophysicist could have imagined the existence of neutron stars. It was first necessary to discover neutrons here on Earth by conducting Galilean-type experiments at the first level of scientific credibility. It was the discovery of the neutron that permitted the elaboration of mathematical models that led to the theoretical hypothesis of the existence of neutron Stars. Quite recently, the observation of certain stellar phenomena has been interpreted as indicating the possible existence of 'quark Stars'. The existence

of this new class of particles, the quarks themselves, however, was discovered here on Earth by conducting Galilean-type experiments at the first level of scientific credibility. This is the link that should exist between the second and the first level.

Moving on to the third. This level of scientific credibility refers to phenomena that occur only one time. At first glance it could seem that the third level contradicts the notion of 'experimental reproducibility'. This is not so. The third level does not in fact leave the first level out of consideration. An example of a phenomenon that happens only one time is that which is described by cosmic evolution. The Cosmos has the Physics of pre-Big Bang as its initial phase. Then comes the Big Bang with Time intervals that range from billionths of billionths of billionths of billionths of billionths of a second (10^{-45}: Planck's Time) to the Time needed for cosmic evolution with the energy of the vacuum (Alan Guth's Time: 10^{-34} sec) to the evolutionary period in which – other than gravitational force – enter into play the Three Fundamental Forces (strong subnuclear, weak subnuclear and electromagnetic) of the so-called Standard Model with its three building blocks of fundamental particles, each of which is composed of two 'quarks' and two 'leptons'. The Time intervals in play for this phase of cosmic evolution are tenths of billionths of a second. And so one arrives at the few seconds necessary for making the Cosmos with the particles familiar to us (protons, neutrons and electrons) and finally the plasma of these particles in the sea of 'photons' that lasts a few hundreds of thousands of years (according to the most recent data, the Time interval is 380 thousand years). At this point the Cosmos, made essentially of protons, electrons and photons, passes into the phase in which the Stars and the Galaxies are born. According to the most recent theories, it could be 'Black Holes' (made with the very primitive form of matter which existed much before the one of the 'Standard Model' particles) that act as nuclei for the formation of galactic structures in which stars are born. The duration of this phase of cosmic evolution is millions of years. After 15 billion years we reach the present with ourselves, the Sun, the Earth, the Moon, the oceans, the mountains, the sunrises and sunsets, the Cathedrals, Michelangelo's Pietà and the incredible detail that in this cosmic evolution there is, in addition to the inert matter, also the living matter, both vegetable and animal. Among the countless forms of living matter there is one and only one that is endowed with Reason. It is in fact thanks to Reason that it has been possible to discover Permanent Collective Memory, rigorous Logic and Science.

3. *The Evolution of the Universe: an Example of the Third Level*

Cosmic evolution is Galilean Science to the extent that it is formulated in rigorous mathematical terms and linked to the first level. From the pre-Big Bang on, everything is based on that which has been discovered at the first level. It is not possible to prove experimentally the reproducibility of cosmic evolution.

No one knows how to make a Big Bang to verify the details that we would like to put under experimental testing. We can only conduct experiments to understand what happens as we come close to the Big Bang. Today we have arrived at a tenth of a millionth of a second (10^{-10} sec). Keeping in mind that Planck's Time lasts 10^{-45} sec, it is wise not to forget that a good 35 orders of ten separate us from the instant before inflationary expansion bursts forth. These 35 powers of ten are the measure of our ignorance in the rigorous knowledge of that which we call the 'theory of cosmic evolution'.

This theory helps us to understand just how difficult the study of phenomena belonging to the third level of Galilean scientific credibility is.

4. *The Evolution in Terms of Galilean Rigor and Experimental Reproducibility*

To this level, we repeat, belong all the phenomena that happen only one time, as in the example of the Biological Evolutionism of the Human Species. Our species being the only form of living matter endowed with Reason, it is well to subject the 'theory of Biological Evolutionism of the Human Species' to Galilean-type rigor.

There are those who say that this 'theory' represents the frontier of Galilean Science. We would like this to be true. To accomplish this, however, it is necessary to establish for this theory a foundation in mathematical rigor and experimental reproducibility. Doing this requires an analysis that is attentive to the phenomenon called 'evolutionism'. Evolution exists at the level of elementary particles, at the level of aggregates made up of inert matter, and at the level of aggregates of living matter.

First of all, a clarification. While being studied, the phenomenon called 'evolution' can reveal itself only in 'Space-Time'. The first rigorous study of evolution at the level of elementary particles concerns electrons. It is not by chance that the electron itself is the first example of an 'elementary particle' (discovered by Thomson in 1897).

Dirac, fascinated by the discovery of Lorentz that Space-Time could not be a real quantity but instead a complex one (if Space is real, Time must be imaginary, and vice versa), decided to study with rigor the evolution of the electron in Time and Space. This was how he discovered his equation.

The rigorous study of evolutionism at the level of elementary particles brought Dirac to discover a reality that no philosopher, no poet, no thinker of any epoch or civilization was able to imagine. This reality begins with antiparticles and brings us to the discovery of antimatter, antistars and antigalaxies to arrive at our world, which seems to be made up only of matter, stars and galaxies, without any antistars or antigalaxies. An experiment to be conducted in the year 2008 in the International Space Station will tell us if it is really true that in the course of cosmic evolution every trace of antimatter was broken down in order to build up a Universe, like the one in which we are living, that consists only of matter. If in our laboratories we had discovered that antimatter could not exist, the problem of a Universe made only of matter would not exist. This is not so. The existence of antimatter was confirmed in a rigorously Galilean manner in 1965. Nevertheless, in the Universe there is no more antimatter.

It is possible to formulate in a mathematically rigorous mode the theory of cosmic evolution that cancels out antimatter at a certain point. According to this theory of cosmic evolution, we are here thanks to the fact that, in the process of 'cancellation', a tiny fraction (one part in 10 thousand million (10^{10})) of matter prevailed over antimatter. No one could say if this theory is that which corresponds to the cosmic reality of which we are a minimal part. The only certainty is that this theory will be scrutinized closely via Galilean-type experimental tests in the years to come.

Starting from the evolution of an elementary particle we have arrived at the problems of cosmic evolution. This means that we have passed from typical structures of the subnuclear world (10^{-17} cm) to galactic structures that reach to the confines of the Universe (10^{29} cm); better still, if the inflationary evolutionism of Alan Guth is true, to even greater cosmic distances. The theory of evolution in the study of inert matter, from the heart of a proton to the confines of the Cosmos, enables one to interlink within a single structure everything that happens in zones of space that are differentiated by at least 46 powers of ten. We have done this using the three levels of Galilean scientific credibility.

This is the most rigorous knowledge we have when dealing with the concept of the evolution of the fundamental structure of inert matter. Let us call this level number 1. The Table below describes the details of this level.

Table 1. EVOLUTION AND SCIENCE

LEVEL NUMBER ONE

I **Evolution in the Fundamental Structure of Inert Matter:**

I-1 **Evolution** in Space-Time of the lightest electrically charged lepton: the **Dirac equation**.

I-2 **Evolution** in the description of the elementary processes involving inert matter: the **Feynman diagrams** and the problem of **Renormalization** (i.e. no divergent results in theoretical calculations).

I-3 **Evolution** in the Universe and in its structure.

I-3-1 The Physics of the **Pre-Big-Bang**.

I-3-2 The Physics of the **Big-Bang**.

I-3-3 The basic structure of matter and of the Fundamental Forces in the Evolution of the Universe: from the **Planck Scale** to present day.

I-3-4 **The origin of Galaxies** and their **distribution** in Space-Time.

I-3-5 **The origin of a Star** and its evolution (Gravitational, Electroweak and Strong Forces).

I-3-6 **The origin** of condensed forms of cold matter (Planets, Asteroids, Comets and others).

The level number 2 refers to the evolution of the macroscopic structure of inert matter. This and the other levels are schematically given in the Table 2 below.

Table 2. EVOLUTION AND SCIENCE

LEVEL NUMBER TWO

II **EVOLUTION IN THE MACROSCOPIC STRUCTURE OF INERT MATTER**.

II-1 The crystals.

II-2 Other forms of conglomerate matter and the understanding of their properties.

THE OTHER LEVELS

III **THE TRANSITION** FROM **INERT MATTER TO LIVING MATTER**.

IV **EVOLUTION** IN THE ENORMOUS VARIETY OF '**NON-ANIMAL**' LIVING MATTER.

V **THE TRANSITION** FROM 'NON-ANIMAL' TO 'ANIMAL' FORMS OF LIVING MATTER.

VI **THE EVOLUTION** IN THE ENORMOUS VARIETY OF 'ANIMAL' FORMS OF LIVING MATTER.

VII **THE TRANSITION** FROM THE INNUMERABLE POSSIBILITIES OF NON-REASONING LIVING FORMS OF MATTER TO THAT OF LIVING MATTER WITH 'REASON'.

VIII **THE EVOLUTION** OF THE SPECIFIC FORM OF LIVING MATTER CALLED 'THE HUMAN SPECIES'.

IX **THE DISCOVERY OF COLLECTIVE MEMORY**, i.e. **WRITTEN LANGUAGE**.

X **THE DISCOVERY OF LOGIC** AND OF ITS MOST RIGOROUS FORM: **MATHEMATICS**.

XI **THE DISCOVERY OF SCIENCE**: THE **LOGIC OF NATURE**.

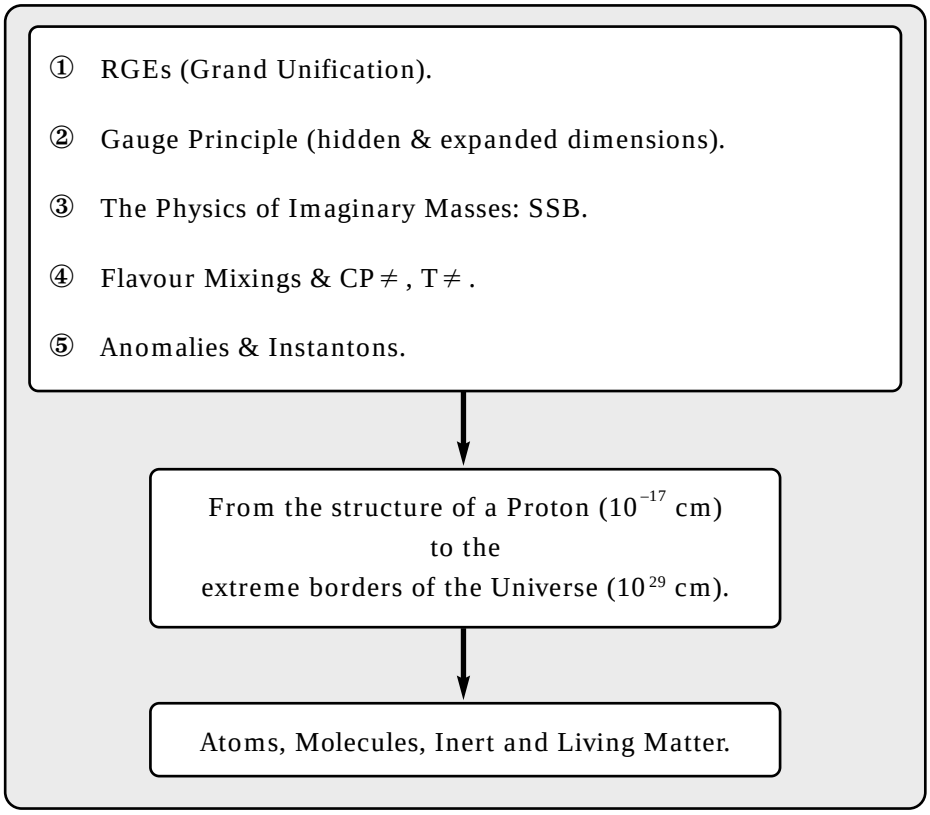
XII **REFLECTIONS** ON HOW IT HAPPENS THAT WE ARE THE **ONLY FORM OF LIVING MATTER** WITH 'REASON'.

All these levels need to be fully understood before we reach the level where we need to think about how we happen to be the only form of living matter with 'Reason' (level XII).

In fact, the extraordinary characteristic of the world in which we live is that the Hardware is the same for all forms of matter: from the most elementary inert element (the electron) to the most advanced form of matter with Life and Reason (the Human Species).

The Table below (Table 3) illustrates the five points that represent the Hardware.

Table 3. THIS HARDWARE (i.e. OUR OWN) OBEYS THE FOLLOWING LOGIC



More detailed information on the Hardware is given in Table 4.

Table 4. DETAILED INFORMATION ON THE HARDWARE

① RGEs (α_i ($i \equiv 1, 2, 3$); m_j ($j \equiv q, l, G, H$)) : f (k^2).
- GUT ($\alpha_{GUT} \cong 1/24$) & GAP ($10^{16} - 10^{18}$) GeV.
- SUSY (to stabilize $m_F/m_P \cong 10^{-17}$).
- RQST (to quantize Gravity).

② Gauge Principle (hidden and expanded dimensions).
— How a Fundamental Force is generated: SU(3); SU(2); U(1) and Gravity.

③ The Physics of Imaginary Masses: SSB.
— The Imaginary Mass in SU(2) × U(1) produces masses ($m_{W^\pm}$; m_{Z^0}; m_q; m_l), including $m_\gamma = 0$.
— The Imaginary Mass in SU(5)⇒SU(3)×SU(2)×U(1) or in any higher Symmetry Group (not containing U(1))⇒SU(3)×SU(2)×U(1) produces Monopoles.
— The Imaginary Mass in $SU(3)_c$ generates Confinement.

④ **Flavour Mixings & CP ≠ , T ≠ .**
— No need for it but it is there.

⑤ **Anomalies & Instantons.**
— Basic Features of all Non-Abelian Forces.

NOTE:

q	≡ quark and squark;	m_F	≡ Fermi mass scale;
l	≡ lepton and slepton;	m_P	≡ Planck mass scale;
G	≡ Gauge boson and Gaugino;	k	≡ quadrimomentum;
H	≡ Higgs and Shiggs;	C	≡ Charge Conjugation;
RGEs	≡ Renormalization Group Equations;	P	≡ Parity;
GUT	≡ Grand Unified Theory;	T	≡ Time Reversal;
SUSY	≡ Supersymmetry;	≠	≡ Breakdown of Symmetry Operators.
RQST	≡ Relativistic Quantum String Theory;		
SSB	≡ Spontaneous Symmetry Breaking.		

The five basic steps in our understanding of nature. ① The renormalization group equations (RGEs) imply that the gauge couplings (α_i) and the masses (m_j) all run with k^2. It is this running which allows GUT, suggests SUSY and produces the need for a non point-like description (RQST) of physics processes, thus opening the way to quantize gravity. ② All forces originate in the same way: the gauge principle. ③ Imaginary masses play a central role in describing nature. ④ The mass-eigenstates are mixed when the Fermi forces come in. ⑤ The Abelian force QED has lost its role of being the guide for all fundamental forces. The non-Abelian gauge forces dominate and have features which are not present in QED.

Since the Hardware is the same, the following remarks are in order.

It could very well have been that the basic Hardware was there, but not Life itself.

It could have been that the basic Hardware and Life were there, but no Consciousness (free will).

It could have also been that the basic Hardware plus Life plus Consciousness were there, but no Reason.

These points are illustrated in Table 5.

It happens that Reason is there with its three great achievements: Language, Rigorous Logic and Science as reported in Table 6.

Table 5.

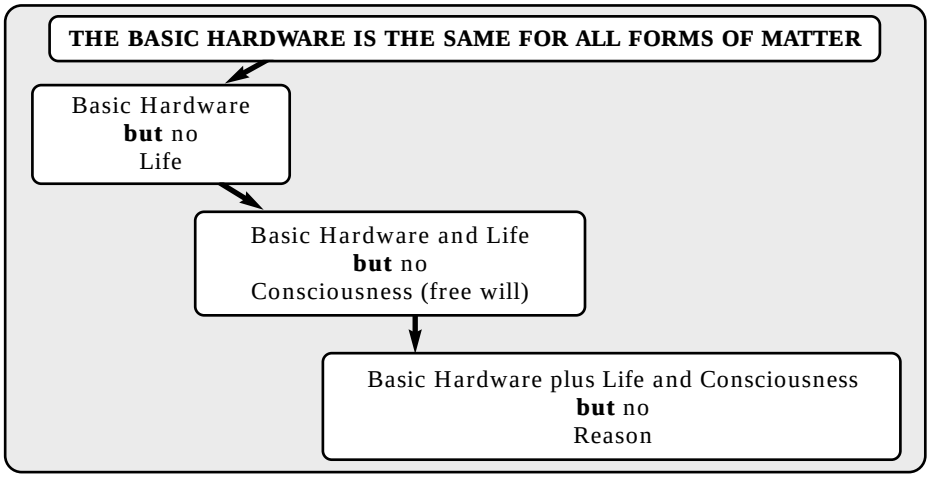
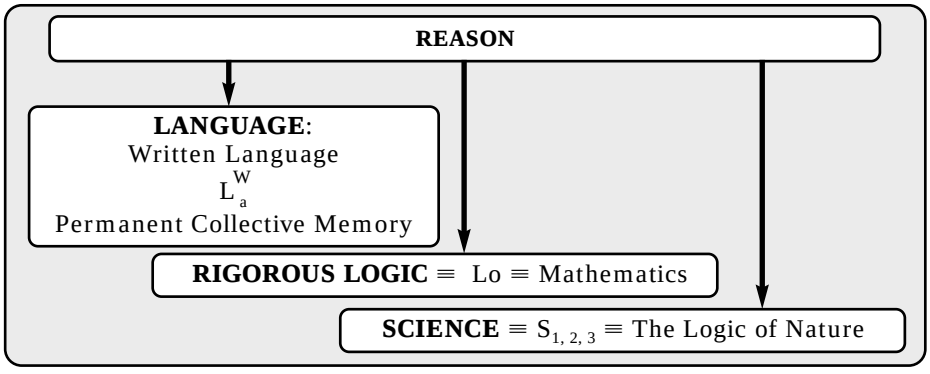
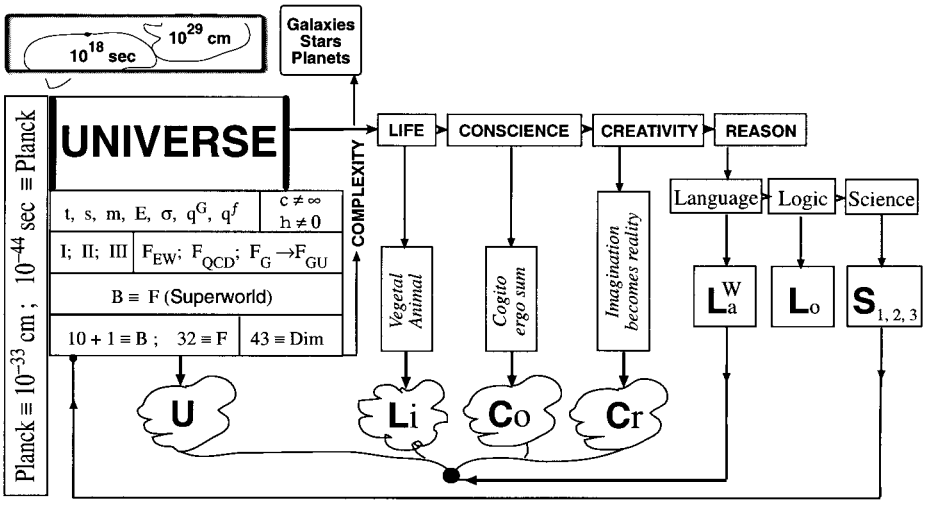


Table 6.



5. *Conclusion*

To conclude: when we speak about evolution we should not forget the basic constituents of Galilean Science: mathematical rigor and experimental reproducibility. The Biological Evolutionism of the Human Species is below the third level of Galilean Science, as can be deduced when we compare this form of evolution with the evolution of the Universe. The Figure below is a synthesis of all I have said regarding the rigorous description of the concept called 'evolution'. A full explanation of this Table would bring us too far out. I have decided to show it to you in order to give you an idea of how complex it is to describe 'evolution' when we want to include all we think we know of the world where we live.



We would like to encourage our colleagues engaged in the study of biological evolution to follow our suggestions in order to reach the goal of bringing the Biological Evolutionism of the Human Species to the third level of Galilean Science, like cosmic evolution.

DISCUSSION ON THE PAPER BY ZICHICHI

JAKI: I've struggled with myself during your presentation whether to make a comment or not, but I decided I had to speak up. When you made the statement – I leave aside such impossible statements of yours that John Paul II opened the doors of the Church to science and similar things – but when you referred to the intellectual humility of Galileo I felt I had to say something, because already from your previous statements, when it came to the history of physics, I felt very uneasy. Now, with respect to the intellectual humility of Galileo, I would like to say in brief only this much: had Galileo's utter pride prevailed, Newtonian science would have never been born. That utter pride forced Galileo to stick with the strictly circular orbit of planets, that utter pride of Galileo, and I'm talking only of scientific matters, that utter pride of Galileo forced him to ignore Kepler's work, the *Stella Martis*, which contained the elliptical orbit of planets, and the utter pride of Galileo forced Galileo to ignore two other books of Kepler, one of them the *Harmonice mundi*, which contained the two other laws of Kepler, and, had it not been for a little-known English scientist, astronomer, his name was Jeremiah Horrocks, who died at the age of 21, just the year he was taken away by the bubonic plague, who put together a readable summary of Kepler's achievements, and had it not been for Horrock's teacher Wallis in Cambridge, Newton would have never learnt of the three laws of Kepler, and without those three laws we would neither have Galilean science, nor Newtonian science, nor Einsteinian science. I deeply resent the fact that an eminent scientist like you, a physicist, can run roughshod over elementary facts in the history of modern physics.

ZICHICHI: Well, I've written a book on Galilei which has 150 quotations. In this book I proved that the acceleration by gravity could have been measured ten thousand years before with the invention of the inclined plane. Without the measurement of the acceleration of gravity, Newton could have done nothing, despite the discoveries of Kepler and all you

mentioned. The key point was the measurement of the acceleration by gravity. Point number two: how can you explain, due to the fact that you think you are right, that for ten thousand years the error in the measurement of time was always one second every day, and after Galilei, now, we've 2 minutes in 20 billion years, and I could do my gadget in 1965 at the level of a few picoseconds thanks to Galilei, not to anyone else. You quoted the circular orbits, and if you read my book, which I would be pleased to send to you, this is the proof that Galilei was a man of faith. Why? Because when he received the news, the discovery of the Mars orbit, which could not be circular but elliptic, as you correctly pointed out, Galilei said, 'No. God could not choose imperfect geometrical objects'. This is the proof of Galilei's faith. You should read my book. In my book I write down all the discoveries of Galilei. And if you read the book and you disagree, write to me, say, page number x, this is wrong. I was very careful in listing the incredible number of correct discoveries made by Galilei. The story of the orbit is fantastic proof against all members of the dominant atheistic culture who claim Galilei was not a man of faith, that he was just afraid of the Church. No. Galilei wrote that he wanted to look for the footprint of the Creator. He died convinced that Kepler made a mistake, because he was thinking about the fact that the orbits had to be perfect geometrical figures, due to the act of creation. So, the proof of Galilei being a man of faith is exactly what you have stated.

MÖSSBAUER: I would like to come to the 10^{-33} centimetres and to the 10^{-44} seconds. We don't know how to quantize gravitation, apart from string theory where nothing is proved. It is mathematical philosophy, you're right, so we don't know how to quantise it.

ZICHICHI: Correct. But the point I wanted to emphasize is that your compatriot Planck was the first man on this planet to realise that the units, centimetre, second and gramme, are just mankind, anthropomorphic: what would be the correspondent values for length, time and mass if the basic unit in nature were taken to be the fundamental constants: the speed of light, Planck action and Newton gravitation? This was the great achievement of Plank. I insist in saying that Planck has not been correctly given the right tribute for this incredible achievement. When we knew nothing about the unification of the fundamental forces, he realised: what are you talking about? Centimetres, no! Let us use the fundamental constants. What are the units? Fantastic. They are still there.

CABIBBO: He was made a member of this Academy on the first possible occasion.

ZICHICHI: Yes, and he should be celebrated, because he is really one of the greatest of them all; it is incredible what he did. And people forget, they start mentioning other people.

PAVAN: I had difficulty in following you and in understanding everything you said, but, since we don't have much time for discussion, I would like you to explain to me what you mean by atheist culture has used so-called popularisation of science to enclose so much cultural untruth. Are you against the popularisation of science?

ZICHICHI: No. I'm for the popularisation of science in a correct way. For example, make a list of the greatest scientists in the history of science who've said science and faith are in contradiction. No one, zero. Nevertheless, if you take a taxi and you tell the taxi driver: 'I'm a scientist, I'm coming from the Vatican', he will tell you: 'Professor Pavan, how can there be a scientist who goes to the Vatican?' I was asked this question in 1979. Now it's different, because in Italy I've been involved quite a lot, but in 1979, and for many years, I was questioned like this, 'You are a scientist, and you go to Church?" *Ubi major est, minor cessat*. You must pick up the most important of all effects if you want to understand anything. You must pick up the number one: how can you justify the existence of this life? This is mystification. I'm against the erroneous popularisation of science. This is why I'm trying to help honest people. I don't know your country, so I can only speak about Italy, but in Italy science popularisation is dominated by atheists at the 99% level.

PAVAN: Not in Brazil.

ZICHICHI: I'm very glad.

VICUÑA: Over these days, Professor Zichichi, you have insisted that science and technology can be differentiated clearly, and we scientists can be searching for the truth and people with wrong intentions can be using this knowledge for technology in various fields, and I would like to come again with a comment I made the other day to you, but there wasn't any time to pursue it, that there are areas in which science and technology cannot be

clearly differentiated, and what I see from my standpoint is that there are many scientists these days in these areas some of whom are colliding with ethical norms that we would all like to respect, and therefore I don't see a scientist anymore as I would like to see, so immaculate just looking for the truth, and some of them are getting into areas which are related to technology, and I don't think they are using the tools and the methods that we would have dreamed for scientists who are after the truth or pure knowledge only.

ZICHICHI: A telegraphic answer: science is the study of the logic of nature. In so far as you study the logic of nature you do science. As soon as you go out of this, you are out of science. I've been involved in technological inventions, in scientific discoveries, so I know exactly that these two items can be clearly classified, and it is in the interest of science, because if you start with a confusion, then the confusion will go on and we should not forget that we reached the stage where John Paul II was the only person on the planet who stood up and made his important declaration when we were accused of being the authors of the earth packed with H bombs. Enrico Fermi is not the father of the Hiroshima bomb; that was Hitler. Edward Teller is not the father of the H bomb; that was Stalin. But try to ask people around, and you see the answer. Why? Because the atheistic popularisation of science has deliberately created the confusion between science and the application of scientific discoveries, i.e. technology. Science is the study of the logic of nature, period.

VICUÑA: Mr. President, one very short question: is the human genome project science or technology, Professor Zichichi?

ZICHICHI: Technology. Applied science. I'm sorry but this is the truth. When you will reach the end, you'll discover the Maxwell equations.

CABIBBO: I don't think many of the people here would agree with you, but we will put it on record as your opinion.

GERMAIN: Je peux dire un mot. Notre confrère Zichichi nous a décrit une science idéale, qui est, d'ailleurs, l'idéal que j'ai de cette science, mais avec sa volonté de distinguer complètement science et technologie. Alors il se met dans une position très facile: pour les scientifiques, les choses ne sont pas aussi simples. Je pense à beaucoup de ce que vous avez dit et puisque c'est la conclusion de notre Conseil, je pense que ce que nous avons à faire,

c'est justement de sauver la science là où elle apparaît dans le monde, et elle apparaît dans le monde avec les applications, et là alors il faut en quelque sort éduquer le peuple, nos concitoyens pour qu'ils apprennent, dans cette espèce de monde dans lequel nous nous trouvons, dans lequel effectivement les applications de la science sont partout, à faire une distinction. Mais dire: 'La science est parfaite et la technologie est tout-à-fait infernale', est une position très facile. Vous êtes un physicien théoricien, alors là c'est facile. Pour d'autres qui ont constamment à faire avec des questions pratiques qui intéressent tout notre peuple, alors la situation n'est pas aussi facile. Par conséquent, je suis d'accord avec vous, malheureusement je crois que votre conférence se place dans un monde idéal qui n'est pas celui dans lequel nous nous trouvons. Merci.

ZICHICHI: Je vous remercie beaucoup, mais je dois dire que je n'ai pas dit que la technologie est tout méchante, non, j'ai dit, 'La science c'est l'étude de la logique de la nature'. Cette logique peut être utilisé pro et contre, mais le choix entre pro et contre n'est pas scientifique, c'est culturel.

GERMAIN: Oui, mais alors, si vous vous désintéressez de savoir comment les applications de la science sont faites, vous vous en désintéressez en disant: 'La société se débrouillera à faire ce qui est favorable, et à ne pas faire ce qui est défavorable'. Nous ne pouvons pas nous en désintéresser. Dans cette Académie nous devons dire à nos concitoyens: 'Oui, la science arrive dans un état des choses compliqué et mélangé, et c'est très difficile'. Alors, il faut les aider à comprendre, parce que c'est eux finalement qui choisissent. Mais nous devons participer, et ce que je reproche c'est qu'avec votre position vous dîtes: 'C'est pour les autres, alors nous, nous avons bonne conscience'.

ZICHICHI: Alors, je répète: la science on ne peut pas la confondre avec ses applications, il faut être rigoureusement logique. Alors, s'il y a une chose qu'on appelle mathématique, ça c'est mathématique, on ne peut pas la confondre avec une autre discipline.

GERMAIN: Les mathématiques, ça c'est facile.

ZICHICHI: La science est la logique de la nature; étudier la logique de la nature c'est science. Les applications de la science sont la technologie. Ce n'est pas moi qui le dit, c'est la rigueur logique. Si on commence à réfléchir, on arrive à cette conclusion. Je pense que nous avons intérêt à faire de la

culture scientifique, et à mettre au point les choses avec une grande clarté et rigueur. Donc, il faut dire au grand et vaste public qui ne fait pas de science que l'on aurait pu avoir les mêmes résultats scientifiques sans avoir une seule bombe. Vous êtes d'accord ou non? Evidemment. Pourquoi a-t-on les applications néfastes de la science? Parce que les applications de la science ont toujours échappé au contrôle des scientifiques, il ne faut pas oublier ça.

GERMAIN: Mais bien sûr, mais bien sûr. Mais c'est normal, je trouve, que les applications de la science échappent au contrôle des scientifiques. Mais les scientifiques doivent s'en occuper.

ZICHICHI: Il ne faut pas dire ça à moi, parce que je m'en suis occupé plus que tous mes collègues en moyenne. Les applications de la science dites technologies, peuvent être avec le signe plus et le signe moins.

GERMAIN: D'accord, d'accord.

ZICHICHI: C'est cela que je dis.

GERMAIN: D'accord.

SURGERY OF THE SOUL

JOSEPH E. MURRAY

I thank the Pontifical Academy of Sciences for allowing me to speak at this plenary session on *The Cultural Values of Science*. As a medical student sixty years ago, I thought of surgery merely as a series of operations developed over the years to: (1) save life; (2) restore function; or (3) relieve pain. Following graduation from medical school in 1943 and a nine-month surgical internship I was drafted into the United Sates Army Medical Corps and served on active duty for three years until my discharge in late 1947. My army experience consisted of surgery on battle casualties from the European, African, and Pacific theatres. This influenced my entire professional life. It was here that I recognised an additional indication for surgery, i.e. to improve quality of life.

VALUE OF LIFE
INDICATIONS FOR SURGERY

1. *Save life*
2. *Restore function*
3. *Relieve pain*
4. *Improve 'quality of life'*

The title of today's talk was suggested by a book editor who happened to hear me speak about my surgical career at Harvard Medical School. My life in surgery has been a fortuitous blend of science and humanity. I chose to attend a small liberal arts college, College of the Holy Cross, and concentrated on Latin, Greek, Philosophy, and English. Assuming I'd receive ample science in medical school, I took the minimum of chemistry, physics

and biology. I entered Harvard Medical School expecting to return to my hometown near Boston as a general surgeon. However, as Louis Pasteur wrote, I was to find myself pulled into pure research through my application of medical school knowledge:

> No category of science exists to which one could give the name of applied science. There are science and the application of science, linked together as a fruit is to the tree that has borne it.
>
> Louis Pasteur

Science and plastic surgery entered my life when I helped care for Charles Woods. Charles is a United States aviator who was 70% burned in a crash flying over the Himalayan Mountains between Burma and China. China was then our ally against Japan. Charles was flown halfway around the world to our army hospital in Valley Forge, Pennsylvania. Here is a slide showing Charles today. He is 83 years old, the same age as I. (Slide 4, see page 382).

The next two slides show Charles as he was when he arrived at Valley Forge Hospital. (Slide 5 and 6, see page 383).

You can see in this slide that we covered his open burns with skin taken from other parts of his body. Charles went on to become a successful businessman. His family and mine have stayed quite close over the years, and I still hear from them regularly.

While working at Valley Forge Hospital on patients including Charles Woods, we often encountered the challenge of covering the burns with skin to permit healing to take place. We sometimes used skin from cadavers, but it was always eventually rejected. I became fascinated with this problem. Thus began my two major surgical interests: plastic surgery, and transplantation biology.

Along the way I have operated on many continents. In India I operated on leprosy patients at the Christian Medical College in Vellore, correcting hand and facial deformities. As with the battle casualties, it was the spirit and the soul of these patients that carried them through their trials. The patients were reconstructed and then taught to use their improved hands in making saleable items. With their reconstructed hands they create hand-

made toys and other items including a wooden plaque bearing the motto 'Difficulties Are Opportunities'. These patients' functional hands give them the chance for employment so that they did not have to go on begging for a living. The sign sits on my desk as an inspiration, an example of the many times that patients have enlarged me with their courage and faith.

As decades passed and surgery became more skilful and safer, we surgeons expanded the numbers of treatable conditions. Birth defects are a good example. Here is a child born in the seventies with severe facial and cranial distortion. (Slide 9, see page 384).

The parents were strongly advised to place him in an institution for handicapped children in order to protect their five other 'normal' children. After two years of weekly visits to the institution with no sign of improvement, the parents took him home. This picture shows him as I first saw him with his twin brother at age seven, after surgery performed elsewhere. (Slide 10, see page 384).

We performed six craniofacial operations over five years to restore some degree of facial, cranial, and orbital symmetry. He then entered the public school system that his brother attended. Unbelievably, he graduated with higher grades than his brother. (Slide 11, see page 385).

It is appropriate to mention during this occasion in Rome that Italy herself has made historical contributions to the field of plastic surgery. Gaspare Tagliacozzi, 1545-1599, was practicing a form of plastic surgery rebuilding the noses of those whose nose had been removed as punishment for crime. Tagliacozzi also recognized quality of life as a reason for surgery:

> We restore, repair and make whole those parts of the body which nature has given but which fortune has taken away, not so much that they may delight the eye but that they may buoy up the spirit and help the mind of the afflicted.
>
> Tagliacozzi, 1597

All surgeons around the world owe immense gratitude to the pioneer surgeon, Paul Tessier, of Nantes and Paris, France, for showing us the way to operate safely on the orbits and skulls to correct craniofacial deformities in infants. This speciality of craniofacial surgery emerged after World War

II. The next three slides show a good example of the application of Dr. Tessier's innovative surgery in infants. (Slide 13, see page 386).

In slide 13 you can see the asymmetrical face and cranium, which we studied carefully before performing surgery. I would take a picture of a patient and cut it up into puzzle pieces, sliding them around to visualise how the operation would proceed. Nowadays of course these preparations are made with the aid of computers. (Slide 14, see page 386).

Slide 14 shows segments of the child's skull which have been detached from the head. These segments were reshaped on a side table before being replaced. This reshaping of the cranium allows the skull to grow symmetrically larger under the influence of the growing brain. At the top of this picture, you can see the bone grafts taken from the child's hip which were inserted into the gaps left by this procedure. (Slide 15, see page 387).

Slide 15 shows the same child post-operatively, with his appearance and skull size near-normal. In addition to observing improved post-operative appearance, parents of our post-surgical craniofacial patients often commented on improved behavior as well.

To proceed to another topic: Organ transplantation is one of the most dramatic biological advances of the 20th century. 'Spare parts surgery' had been dreamed of for centuries. Throughout our travels I sought out depictions of the twin Saints Cosmos and Damian. (Slide 16, see page 388).

According to legend, Cosmos and Damian were physicians who successfully transplanted the limb of a dead Moor onto a patient whose leg required amputation. It was almost as if fate had decreed that identical twins would play a role in successful organ transplantation. You can see in this slide the twin saints attaching the black leg to their lighter-skinned patient.

In the early 50's, organ transplantation was considered an impossible dream by practically everyone – except surgeons and physicians caring for patients with severe burns or severe kidney disease. Drs. Barrett Brown and Brad Cannon, Chiefs of Plastic Surgery at Valley Forge General Hospital, had used skin from dead persons to temporarily replace skin in burn patients. Nephrologists had experimented with hemodialysis as a temporary substitute for diseased kidneys. Brown had shown that skin exchanged between identical twins could survive permanently. (Slide 17, see page 335).

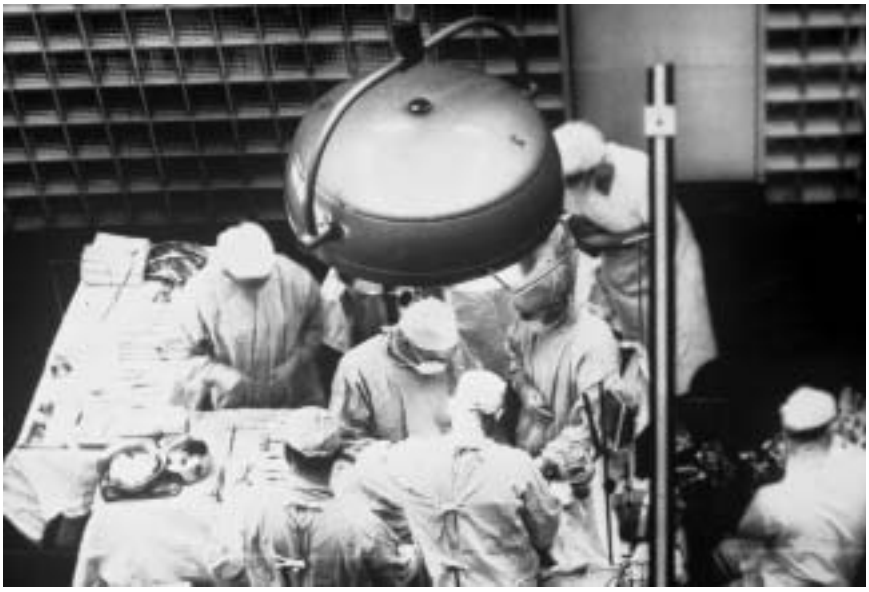
In this slide you can see identical twins displaying the successful skin grafts where a small patch of skin from the forearm has been transferred to the other's arm.

With the case of Charles Woods in mind, after the war I eagerly joined the transplant team at Brigham Hospital and Harvard Medical School in Boston.

Slide 17. Brown's twins.

Soon I had developed a predictable operation for kidney transplants in dogs. At the same time, hemodyalisis was first used at the Brigham. A patient was referred for terminal renal failure who had an identical twin brother anxious to donate one of his kidneys. We did go ahead with the transplant operation, but only after serious consideration of the many ethical problems involved. We met first with a number of doctors and clerics as well as with the family members to discuss the concept. (Slide 18, see page 336).

This slide of this historical operation shows the transplantation team preparing the sick twin to receive a kidney from the healthy twin, who is being operated on in an adjoining operating room. Following five weeks of excellent function of the transplanted kidney, we had a decision to make about removal of the diseased kidneys. I favored removing the diseased kidneys immediately, while my colleague wanted to leave them in place as a backup in case the transplant did not 'take', and with the hope that they might recover. After discussing the situation with my superior, I bowed to my colleague's wishes, as he was the medical doctor in charge of managing the renal disease. Later we learned that diseased kidneys should be



Slide 18. Intra-op photo of kidney transplant operation.

removed so they do not infect the transplanted one, but at the time we were all doing what we thought was best. (Slide 19, see page 337).

Here are the young men leaving the hospital after the successful operation. The sick twin is in the wheelchair, which is being pushed by the donor twin. The recipient lived for another seven years before dying of renal failure after he developed the original renal disease in the transplanted kidney.

Chief of surgery Dr. Francis Moore commented years later that as a result of this accomplishment, the ethical assumption of physicians 'to do no harm' would be forever challenged.

None of these advances could have occurred without the benefits of animal research. Our research lab, where we developed our transplantation techniques, depended on the most careful care of our animals. They were treated like royalty in every way. But even though we protected them to the best of our ability, two of them managed to get together when Mona was in heat, and she presented us with a healthy litter of pups as you can see in the next slide. (Slide 21, see page 339).

This unexpected event proved fortunate, as we did not know whether the immunosuppressive drugs would interfere with pregnancy, or whether

Slide 19. Twins leaving hospital.

they would lead to birth defects. Since then we have learned that neither is the case, and there have been many successful pregnancies within the population of transplanted patients living on immunosuppressive drugs.

The success of this first twin transplant in 1954, followed by a successful sibling transplant in 1959 and a similar successful transplant from a cadaver in 1962, opened the door for worldwide transplantation.

INTERNATIONAL TRANSPLANT SURVIVAL RECORD
Longest surviving recipient with continuous function:

Kidney	31 years	Heart	23 years
Kidney-Pancreas	13 years	Heart-Lung	11 years
Pancreas	16 years	Single Lung	8 years
Liver	24 years	Double Lung	7 years
Bone Marrow	20 years		

This table shows the longest survival times for kidney, heart, liver, kidney-pancreas, bone marrow, heart-lung, single lung, and double lung transplants. At the time that we were developing the kidney transplant operation to benefit our patients with severe kidney disease, none of us had any idea that these other transplantation surgeries would soon become possible.

The transplant story comes full circle in the next slide. (Slide 22, see page 389).

Here we see a young man who has undergone a successful double hand transplant holding in his transplanted hands a copy of my book, *Surgery of the Soul*. Dr. Max Dubernard of Lyon, France sent me this slide recently, and it certainly illustrates the far-reaching impact that our original research in the dog lab and with identical twins has had in our culture. During my career, research pursued in the care of patients has shaped the direction of medicine and indeed has affected our society's culture.

In closing, I would like to read excerpts from a patient highlighted in my book.

The full benefits from plastic surgery are epitomized and encapsulated in the care of one extraordinary human being, Raymond McMillan. Ray was born with severe facial deformity. With no control of his facial muscles, he drooled constantly. His lips were blue and cyanotic. His tongue hung out and his ears were only little blobs of tissue. He was diagnosed as Moebius Syndrome (a not uncommon congenital facial problem) and he also had a heart defect.

Ray had an exceptional spirit despite the physical and emotional hardships he had endured since childhood. After spending the first five years of his life with his mother, he was sent to live at the Wrentham State School (Chapter 17), the same mental institution where Jimmy Hickey had been.

Slide 21. Mona and pups.

Ray survived the next 16 years there, and was released at the age of 21. One year later, he was referred to us at the Brigham by either a local newspaper editor or a parish priest.

Ray's problems were so extensive that it was difficult for us to know where to begin. After study, we decided to tackle his facial deformities first, because it was his most visible and compelling problem, and also the most easily repaired. At that time, in the late 1950s, cardiac surgery was non-existent; heart-lung pumps were still undergoing research development.

We started our reconstruction by dividing his lower jawbone into two sections and repositioning each section so that he could close his mouth and control his saliva. A few months later, we detached portions of whatever functional facial muscles he had, and reattached them to the corners of his mouth. This gave Ray the ability to smile, albeit in a limited way, for the first time.

Subsequently, we operated on his palate to help improve his speech and made revisions to the shape of his nose. These moderate improve-

ments increased his self-esteem, another example of a slight physical improvement being more beneficial than an onlooker – or even the surgeon – might expect.

By the next decade, cardiac surgery had progressed remarkably and. Drs. John Collins and Larry Cohn were able to repair Ray's heart, giving him considerably more strength and stamina.

Ray lived alone and was self-sufficient. I helped him get a job in one of the labs at the Dana-Farber and Children's Hospitals and, on his way to or from work, he frequently dropped by my office. I enjoyed these casual visits and, during one of them, suggested he study for his high school equivalency diploma. A few years later, he bounded into my office, waving his diploma. I was deeply touched when he asked if I would keep it! I suppose in some way I had become a father figure to him.

Later, I suggested he do some writing. Apparently he acted on my suggestion. These excerpts from his unfinished memoir, uncovered after his death in 1997, were written as Ray sat on a park bench in the Boston Common. This is where George Washington took command of the American troops and began training them for the American Revolution.

'*It is a beautiful day*', begins Ray's memoir. '*I have a wonderful free, serene feeling just watching the people go by. I am writing this in the hope that it might help someone today.*

This story begins with despair and ends with hope. My name is Raymond Francis McMillan and I was born in Malden, Massachusetts on January 15, 1943. I spent my first five years with my mother, whom I never really got to know.

Because of my deafness, malformed heart and facial deformity, my mother and two social agents admitted me to the Wrentham State School. The School is situated in the New England countryside thirty miles from Boston. The oppressive Victorian buildings of a state hospital still stand, symbol of a time when people abandoned those with whom they could or would not deal. Historically, the hospital was the home of the unloved, the indigent, the handicapped and the insane. It was the total world and experience to thousands of emotionally bereft people. The corridors echo with neglect suffered and cruelties done. And the institution was more like a prison, instead of a mental hospital. It was the antithesis of a nurturing environment; it was an unlikely place for me with my handicaps and I did indeed survive! I survived because I was blessed with a beautiful intelligence, humor and courage. Today I enjoy a normal life and a bright future.

While I was a resident at Wrentham State School, it took some time to get used to because I was very young and I was scared, lost, lonely and confused. My 16 years were a total nightmare and I wonder how I ever survived under those conditions and still was able to keep my head on straight. I was no longer wanted and I found it very difficult to live with the idea of being rejected by my own mother and family because of heart, hearing, and facial malformation. My family only visited me twice during my ordeal. My father came to visit me when I was 12; my stepfather came to visit me five years later and I saw my mother for the first time then. But that was the last time I saw either of them!

I got about four years of good education between 1959 and 1963. Of course living at the School was an education in itself. Under the circumstances I did my very best but I did not graduate nor did anyone else. There was no such thing as a high school diploma at a mental institution.

The people who were in charge at Wrentham State School did not think or feel that I could make it on my own in the outside world because of my handicaps and poor health. The longer I stayed at the institution the more angry I got and I can't count how many times I ran away from the place. When I got caught I knew I was in trouble and after so many beatings it became an everyday thing.

I was paroled (that's the word they used in those days) in April, 1964 at the age of 21. Boy was I glad to see that day come! I knew I had a long hill to climb and it wasn't easy at first but I was so happy to get out of the place they call Wrentham State School that I never looked back! I was not in the best of health but I was so excited to get out on my own for the first time. It felt so good to be free!

"... to preserve freedom, we must begin with peace within ourselves and then spread it to others. Freedom is not a store-bought commodity. There are many ways freedom can be preserved, but with every freedom there is a responsibility and with every right there is an obligation ...". Vida Ivanouskas

On my first day on my own in the outside world, the weather was beautiful. It was a Friday. My first stop was at the White Swan Motel where I was to share a room with three other former residents of the Wrentham State School. The next day I went out looking for an apartment because I wanted total independence and wanted to be alone to prove to myself that I could make it on my own and in the community. I became a dishwasher and salad bar helper at the Lafayette House Restaurant.

My first year, 1964, was a very difficult year. I had trouble making the transition and I didn't know to whom, where or how to go for help. I didn't speak English very well since I had very defective speech. It made it very difficult to

talk. Abraham Lincoln once said: "Most folks are about as happy as they make up their minds to be". You know, he was right! The following year, 1965, I promised myself to be so strong that nothing could disturb my peace of mind. To talk health and make all my friends feel that there is something in them. To look on the sunny side of everything and make my optimism come true. To forget the mistakes of the past and press on to the greater achievements of the future. To wear a cheerful countenance at all times and to have a smile ready for every living creature I meet. To give so much time to the improvement of myself that I have no time to criticize others. To be too large for worry, too noble for anger, too strong for fear and too happy to permit the presence of trouble. To think well of myself and to proclaim this fact to the world – not in loud words but in great deeds. To live in the faith that the world is on my side so long as I am true to the best that is in me.

That same year I had an appointment with Dr. Joseph E. Murray, a plastic surgeon at the Peter Bent Brigham Hospital. He told me that he could help me and make my life a lot easier to handle. As the years went by I continued to see Dr. Murray even until this day. Throughout 1965 I spent a great deal of time as an outpatient. Four to six months was spent getting my jaw ready and strengthened for my first operation in 1966. I didn't know what to expect of the outcome but I knew there was a lot of work to be done and that I would have to be strong and have a lot of heart and to be brave and courageous and to do what is right and to take responsibility for my own actions. I expect nothing from the world but I realize that as I give to the world, the world will give to me.

I had my first operation in 1966, and addition operations in 1967, 1968 and 1969. They could only do a little at a time because I had a weak heart. Then in 1970 I went and had the open heart surgery and I was in the hospital for about seven weeks. I can honestly say they did a wonderful job. The surgery was performed by Dr. John Collins and Dr. Lawrence Cohn. I had my last operation in 1977. In the meantime, I did a lot of reading as part of my self education. I couldn't read well or understand all that I was reading. I kept on reading anyway!

Many people have severe facial deformities, either congenitally or as a result of injury or disease. They do not look like other people and because they are different, they are treated differently. They may even come to think of themselves as less than human. But beauty is not determined by a perfect figure and features. It is determined by the way you respect and honor yourself.

I had a very difficult time with my handicap and sometimes I had to fight with my fists. I had to fight to survive. Handicapped people are a part of our

society that are beaten down time and time again. But we are a strong-willed and extremely proud people who desire no handouts, no charity and want nothing more than the simple chance to support ourselves through our own abilities. There are ups and downs and you can never be a quitter. There is a reason for living! There is a reason for being here. And there is always a way. No matter what you are going through, there is always a way'.
Raymond Francis McMillan

Ray died suddenly in 1997, seated in a car beside his best friend, on the way to lunch at a favored restaurant. At his funeral, a circle of people far beyond his hometown of Wrentham came to mourn his passing. Many described Ray as a beloved friend. Jack Collins, Larry Cohn and I agree that Ray was one of the most remarkable patients we have ever had the privilege to care for. We feel fortunate to have known him.

The impact the hospital staff and I had on Ray's life only partially involved scalpels and sutures. Simply because we cared for him and showed him compassion and basic human kindness, we gave him a feeling of worth and helped heal his spirit. The greatest benefit we gave Ray was not so much the freedom of facial muscles, but rather the freedom for his inner self to glow and grow. The cosmetic improvements we made to his exterior simply removed what had been a constant impediment to his daily living. Surely this was a case of “surgery of the soul”.

ANTHROPICAL COSMOLOGY AND PERSONAL THEOLOGY

NICOLA DALLAPORTA

If by 'culture' in its strongest meaning we understand the totality of knowledge at any possible level contributing to the construction of a world picture as extended and complete as possible, we should easily recognize that such a picture must include all the domains of thought present in our psychical being; and we instinctively feel the impulse to connect to each other such domains in order to form a general coherent frame of reference into which any viewpoint finds its adequate location. What I am proposing here to present of such a vast frame is one of those possible connections, related on the one hand to science, as requested by the theme of this conference, and on the other to one of the most conspicuous fields of internal investigation, for almost anybody I might venture. In fact the main cultural and most valuable derivation yielded to me from science is its contribution to the growing of my understanding beyond the sensible evidence and the logical rationality. I will therefore try to show how, at least on my personal account, the evolving picture of science during the decades of my living time has gradually contributed to develop, extend and increase my metaphysical and religious approach to reality.

We will try, above all, to update the view by which we can look at the cosmos today.

The body of opinion has been, during the last few centuries, the preferred ground for the development of what, under the generic name 'science', has been constructed as a body of self-convincing and autonomous knowledge, according to an outlook which is essentially mechanistic. Today however, after a long period in which determinism seemed to dominate uncontested, a picture of the physical world is spreading more and more, based both on the microscopic domain which is subject to quantum mechanics, and on the so-called 'deterministic chaos' of complex systems;

for both the exact predictability of physical phenomena, once considered the essence of physics itself, seems, instead, to be a type of limited case that acts as an excellent approximation only in very simple problems which are defined by a small number of variables; whereas real situations range from sets of molecules to galaxies of stars. It is such complications that make it practically inconceivable to analyse them in detail. Complications of this genre have become the daily bread of all that which goes under the name of complexity, from fluid dynamics to multi-molecular structures which are present in every aspect of biology. Consequently, the general explanatory picture of the physical world is gradually moving away from the idea of exact predictability of the future, which inevitably follows from detailed knowledge of a given initial situation, towards an unpredictability, which generally increases as the length of time increases. Therefore the prospective of 'total necessity', inherent in the Galilean laws of physics, was inevitably overlapped by a zone of growing cognitive indeterminability, which made the future less and less predictable.

Independently of the preceding developments the fundamental idea itself of strict causal deduction of one physical phenomenon from another, also found itself confronting an interpretative difficulty because the situations under consideration had become complicated. If, already, an excessive number of variables, as for example the total of the coordinates and momenta of the component particles of a gas, had asked, in dealing with it, recourse to purely statistical considerations, a heterogeneous system, formed by chains of diverse atoms, which one meets in macromolecular chemistry, seems to make almost obligatory a vision in which one can only deal with by simplifying and appealing to 'randomness'. It is on 'chance' in fact that the Darwinist vision of biology is founded. Now, instead, various researchers, on the basis of the most recent scientific results, are realising how biological experimentation is bringing to light the insufficiencies of Darwinism in explaining several of paleontology's fundamental data. Without going into detail, it is enough to specify that the attribution, due to pure chance, of the meeting between various biological molecular groups would require a period of time billions of times longer than the life of the universe; therefore the state of our earth would constitute, in itself, a type of 'miracle', accomplished once and for all, in spite of all predictable probability.

If the concurrence of billions of micro-causes between the constituent atoms and molecules, over a period of time billions of times longer than the life of the universe, is required in order to form any portion of living substance, it appears clear how, in order to deal with the physically 'complex'

situations, it is opportune to devise new ways of thinking: first, that of overturning the sense of time, and instead of starting from the antecedent of the past, fix instead on the future, and therefore on the 'ends' which can be accomplished for any phenomenon. Physically speaking, the symmetry between past and future is an integral part of a four-dimensional vision: it is only the unidirectional flow of time which, for the human mind and life, differentiates it in such a large manner. Precisely for this reason, one would maybe expect that, with the polarization on the future, our intelligence could enter into a new perspective, complementary and integrating with that, which up to now, was confined to science.

That expectation, as is well known, has been encouraged by biology: if the large variety of micro-causes which play between the molecules makes a decipherable analysis of their reciprocal interactions extremely difficult, the final destination for which this complexity aims, comes together in a set of relatively simple properties, which summarise the objectives and the way that this complexity 'lives', that is eats, drinks, breathes, mates, reproduces; otherwise, it gives way to certain functions un-analysable in their microscopic detail, but it is the 'total behaviour' which forms that which constitutes a plant, an animal, a living being. For this the biological morphology, in its complexity, is much better described by this set of 'finalist' properties than by the unreachable multiplicity of the sets of micro-causes.

For this reason, from the view of the beings, it seems a general directive has almost emerged that alternates from the complementary prospective of 'causalism' on the one hand, 'finalism' on the other; in situations which are physically 'simple' the first is undisputed, whereas in those which are complex the latter is prevalent. This explains why, in the physics of Galilean phenomena only causality seemed necessary to explain the connection between these phenomena, whereas for those which, plausibly, are central to the biological structure, it is the 'finalism' view which, maybe, better captures the sense which we try to find in the panorama which surrounds us and in what we are. The complicated pass from the physics view to that of biology, is the crucial point which, to be understood, probably requires the superimposition of the two views, key to the unifying approach to that which is unexplainable around us and in us.

Does there exist maybe, today, some field within which it seems that this type of superimposition occurs? We think that there is, and consists of that set of data which goes under the name of 'anthropic observations'. Without going into too much detail, we will satisfy ourselves by emphasising how this perspective originates, in the ambit of physics itself, not

with the usual question of 'how?' a certain phenomenon occurs, but 'why?' it happens.

As is well known, the general laws of physics depend on a certain number of fundamental constants – such as the speed of light, Plank's constant, electron mass and charge, intensity of various types of forces and so on – which we take for that which they are; and we observe that, by these micro-laws, complex, physical structure results as being capable of becoming the receptacle of life. It can easily be verified that if certain of these fundamental constants are changed by a few percent of their actual value, the physical substrate which leads to living beings would not have been realized in the universe. We do not intend to go over the reasons which lead to these observations here and are, in general, well known in scientific circles, in the strict sense of the word. Here we limit ourselves by assuming that such anthropical observations are a given fact and deduce the likely consequences.

To try to reduce to a purely 'casual' coincidence this unforeseen and sometimes very precise correlation between values of the fundamental laws of physics and the beginning of life, the so-called theory of the 'infinite universes' was created, in which each of these universes is equipped with one of this infinite combinations of all the possible values of the fundamental constants. It is then clear that, for almost all their entirety, the constants chosen by chance are inadequate to allow life to establish itself; this is possible only where the constants are correct, as therefore in our universe – and in few others. Nothing wonderful, then, about such a correlation between the fundamental laws and life; such is the explanation with the 'casual' presence of the infinite universes in the basic structure of the cosmos.

Why then, the invention of such a complicated theory with infinite universes of which, as far as I am aware, we don't have any indication in experimental observation? It is, therefore, to escape a metaphysical implication which could link the beginning of life with a 'preordained plan' chosen before the fundamental laws, and to escape in this way from having to postulate a non-casual nature of the cosmos and mankind.

It is worth noting that this objective contradicts itself right from the beginning: there would be nothing to say against the hypothesis in itself, if not for the fact that it is often viewed as a 'physical' hypothesis, whereas it is a purely 'metaphysical' model. To be 'physical' these infinite universes would have to be observable by us in some way: but since until now nothing has been seen, it is pure hypothesis in a field which has nothing in common with experimental science. Therefore, to avoid the metaphysical interference of a 'prior plan' that foresaw the beginning of life in the cosmos, and

therefore a 'Designer', scientism has invented an alternative hypothesis; but nevertheless it is metaphysical: this the only approach of the 'infinite universes' theory. The conclusion is in the fact that the anthropical observations cannot be explained with only physical arguments: and so a metaphysical finality which cannot be renounced emerges with the following inversion: if the laws of physics permit the passing from microphysics to that of the living structures, it does not appear to be prohibited to think that the microphysical world was chosen as such, so that it could derive the structure suitable to sustain life.

Naturally, such a proposal goes beyond the scientific views of anthropical observations: it transforms them into an anthropical principle, which is taking its place in the field of not physical but metaphysical cosmology. It is clear then that, scientifically speaking, nothing is prohibited, to those who want to adhere to the scientism view, appealing to the metaphysics of the 'infinite universes', as the experimental field, based on empiricism and reason, does not contain anything in itself which can supply clues about the true metaphysical. But if I, in so much as I am a man, spontaneously feel a need to adopt one or other metaphysics, I do not feel any hesitation in declaring my personal conviction that the anthropic view, that is the intentional primordiality of the project 'man' in the cosmos, assumed as a principle of cosmology, seems immensely more likely and convincing than that of the 'infinite universes': above all because of the role of exception that is attributed to life in the economy of the universe; and for this reason, as now we will try to acknowledge, not only to the physical nature, but also to the metaphysical in man.

If the majority of the conditions which allow the creation of biological beings in the cosmos refer to how to make the substrate of purely bodily life – which may be sufficient for inferior life-forms – much less, and in a less precise way, is to be said for those necessary to create the psychic level; and even less for a spiritual being; for the prevailing opinion is that we still know very little about the relationships between body, psyche and spirit. In spite of this, the fact that the name 'anthropic' is given to the above-mentioned observations demonstrates that the deep reason for our interest in this is, not only that they join the cosmos with life, but above all, because they form the first steps towards linking the cosmos with human life.

And what allows us to arrive at the creation of man? Not only a very long period of evolution, but more than anything else that, in the sequence of biological forms of more and more complex molecular structures, a point of stoppage is inserted to a given structure, that stamps a unique hall-

mark, special, foreseen in all the great religious traditions and expressed succinctly in the Bible: man as 'the image of God'.

We will certainly not try to comment on this biblical definition. We are convinced that any human babbling cannot dim the implications. And if therefore, despite its total incomprehensibility, we are now pushed to mention it, it is because we find it accomplished in us, on this earth, and are pushed to the following conclusions. If man appeared in the cosmos, and if the corporeity of this terrestrial world is controlled by the laws of physics, the obvious suspicion arises that it was foreseen that this cosmos must bring man into being. And if such correlations exist, why can't they be more drastically confirmed? That is if the laws of physics are exactly as they are, it was to allow the physical world to be a substrate suitable for the creation of man. In such a perspective, man appears then to be the end for which God created the world and man becomes the destination of the whole of creation.

If, in the field of physics, we believe that one can go further forward only with difficulty, there is nothing to prohibit us from taking further steps forward in the realms of metaphysics, which can, and in fact must, encourage the reconciliation of the apparently distant levels, but converging in a synthesizing picture which encloses them. If man, as 'the image of God', can be considered the ultimate purpose of the creation, is it not, maybe so, that in creation there would be a being which as 'the truthful image', would be suitable to host God himself the day in which He wanted to manifest himself directly to the world, not in His transcendence, but in a form accessible to the eyes and the human senses? For this reason the anthropic vision of the cosmos is really that which, leaving us to glimpse a structure suitable for the Incarnation, lends itself, better than all others, to support a metaphysically Christ-centred view. This reflection, it seems, aims to prepare for the bringing together of the two perspectives mentioned in the title of this paper. And from this point on, I cannot do other than emphasise that which for me constitutes the true metaphysics, with all due respect for the different opinions that many may have regarding this. If indeed the view of the cosmos was modified by the moving from the interests of the field of physics to those of biology and therefore human, a shift in a certain corresponding way, must obviously plausibly result in the centrality of the metaphysical, which moves us from a prevalently impersonal view to that which highlights some other Aspect of the Infinity of the Supreme Origin itself.

Maybe the metaphysical, which seems to lend itself better to a comparison bringing together how, in the western view of the cosmos, 'nature' was

intended, is the dominant Entity of the Hindu metaphysics 'Brahma nirguna', totally boundless and indeterminable, of which it cannot even be said to be 'One' but rather 'non-dual', because even the idea of 'Unity' would be too restrictive; and less often is 'Brahma saguna' referred to, the divine Aspect defined as Being, whose relationship with creation is 'personal', essentially tied to man.

Now this personal Aspect of God, secondary in India, is the prevailing conclusion from when the central point of the divine Attention moves towards Syria and Palestine to manifest itself to Abraham. And it is from this moment that the history of the personal God is given prominence, the protagonist in the events which will happen in the Occidental theatre, leaving the divine Impersonality in the metaphysical background.

It needs to be immediately noted how this passage, in the view of man, is fulfilled by various centuries, and perhaps a millennium, before any grasp of understanding of the physical field of our world. Therefore, when at the beginning of the 17th century, the experimentation and rationalization of Galileo and Descartes established the scientific view, the separation between the metaphysical-religious point of view and that of the physical-scientific was all but complete, to the extent of a practically total split in the 19th century between metaphysics based on the God-person and a physics which obeys the Impersonality of the laws of physics.

This is, in my opinion, the origin of the absurdity that has run rampant for at least three centuries in western culture about the incompatibility between science and religion. I have tried in various occasions to demonstrate that such an incompatibility does not exist and I have generally done so making a comparison between the physical view of the world and the impersonal view of God from the Hindu point of view.

But if now the main body of opinion in the world tends to shift more and more from the physical towards the biological, and centres itself on man, it will appear natural to spiritually jump on the related metaphysical step, for which, from Abraham's Revelation onwards, the divine Personality emerges from the 'Impersonality', dominant until now, to appear like a new protagonist. And how is it that such a divine Personality manifests himself if not through the word of the Sent, of Messengers, of the Prophets, of the 'Avatara' to use a Hindu word, human Spokespersons who speak of what surpasses the man, but which only in man is reflected and takes voice. In this way, by a double movement reciprocally inverse to the perspectives, physics on the one hand and metaphysics on the other, both tending to unity in man, notwithstanding his apparent cosmic insignificance, who

finds himself to be the element in which the creation is summarized, chosen as a support and as the conclusive element in successive theophanies in which the Divinity is revealed all along the whole of the creation events.

As it follows naturally I would now like to demonstrate, not only how man's role corresponds to the specifically Christian view, but that, in a certain sense, it is its most immediate accomplishment; not contenting ourselves, of course, with the superficial but diving into the deepest theological doctrine which today is most explicitly expressed in its fundamental centre which is intact and complete in the Eastern Church, in Orthodoxy.

In fact, the Truths on which the present Orthodox Church is founded are, in their totality, the fruit of the first seven Great Ecumenical Councils held at Constantinople or in the Middle East prior to 1054. Now before that year the schism between the Eastern and the Western Church still had not happened. The significance of this is that this Truth was not only typical of the Eastern Church but represented the belief of the whole Christian Church. And even if, with the addition of the famous 'Filioque' the Roman Church broke away from Orthodoxy, it is a fact that the doctrine that was to be discussed there, which was before the schism, was at the basis of the two churches. And if the Western Church, because of various events in its history, made revisions which moved it away from certain aspects of its origins, the fact remains that these basic aspects, even if they are often neglected or toned down in different ways, are still inherent in its belief. The significance of which is that we are induced to evaluate the observations which here we will develop not as a focus on the characteristics of Orthodoxy but as the hidden centre, also when not explicit, of almost the totality of original Christianity itself.

I must for various reasons, limit myself to touching on only three essential points that I have in mind and do so in such a way as to emphasise both that which is shared and that which particularity distinguishes the Christian view from the other great traditions. On this premise of intent, it is necessary to start, for each of the points to be considered of the exemplified metaphysics, from the formalization of Hinduism, in order to reveal that which precisely defines the exceptionality of the Christian view.

First of all we will consider the relationship between the transcendent and immanent aspects of the Deity in both traditions. The absolute Reality, whatever it may be, is enveloped in all the wrappings of Maya, the cosmic illusion, which can be represented as a series of veils of varying thickness hiding one behind the other until finally the ultimate Reality appears. In the case where a veil is sufficiently transparent and part of the divine light

manages to shine through it, this makes us feel God as immanent in the whole of creation. But when the veils are thick and block all the signals behind them, this then is God as an inaccessible part of the cosmos and seems to be transcendent and totally unknowable in comparison to the weaknesses of humans means.

Now, even if the image of the veils isn't taken up in the ancient Christian tradition, this in itself is not enough not to make use of a symbol which, nevertheless, allows an equivalent type of deduction, as explicitly confirmed by many Fathers of the Church: the distinction, in the divine Nature itself, between that which forms the Essence and that which manifests itself as its Energies. And if the first, the Essence, is in itself unknowable and incommunicable, it is not the same for the Energies. In fact a religion, to be such, cannot only consist of a theology in the abstract which counters the Creator with the created. Its ultimate end cannot be but a road, that which takes us from the existing state upwards, approaching the One who, unknowable in himself, must leave us to discern from some signs which reveal, to those who seek them, the right direction to travel along. Given that the Essence of God is inaccessible and impenetrable to man, it is necessary to direct him to the correct path which, in some way, God communicates, always in Himself, but outside His inaccessible Essence, through the Energies or divine Operations which are an intrinsic part of His uncreated Nature, but which allow Him to proceed towards the external, to be communicated, to give of Himself. And this independently from whatever His surroundings, also in the absence of creation and even before the creation, God, in His incommunicable Essence manifests himself, nevertheless, through the irradiation of His Energies.

Thus we recognise that God is, as for India, immanent and at the same transcendent, totally transcendent in his incommunicable Essence and immanent in the cosmos through His continuous interventions with the multi-form Energies.

The first large distinction in the area of the non-created Nature of God which we have now mentioned between the Essence and the divine Energies, gives us the answer to another point regarding the nature and the role of the Sent or the Lord's Messengers. All of these, according to their own tradition, are bearers of the Word of God and, in some way, are sharers of a certain 'something' inherent in the divine Nature itself. If the Sent announces even only 'something' of such a Nature, the question immediately arises as to what depth of the divine Nature this 'something' must be related. The answer does not seem in doubt, the function of the

Sent, at whatever level he places himself, is that of demonstrating to the world this 'something'. He is therefore part of the divine Nature which is made known, which irradiates, which erupts out of Himself, he is part of the divine Energies, the Saints, the Prophets, the Sent and the Avatara demonstrate him in their profound essence, they are the irradiation rays of the Lord's Nature.

The third point that I wish to consider is in itself the decisive approach for an adequate evaluation of the role of Christ with respect to all the other great traditions. And this decisive point concerns that which until now was mentioned with a single word; the 'unknowable', as regards the Essence of the Deity, which we will try now to explain as far as possible.

Generally, a metaphysical system which wishes to represent the entire cosmos, gradually spreads in manifestation from the top down through the various levels, first informal (non-representational), then psychic formal and finally bodily formal, and the different steps little by little make our understanding of the premise more specific and detailed. For this reason it is a 'positive' theology called 'cataphatic' in that every level reached contributes to a better explanation of what was contained in the cause which produces it. Therefore, going back to the Principle, it becomes more and more specific and detailed from the body of knowledge which derives from Him, knowledge however which is incomplete or imperfect in that the infinite God can never be reduced to a finite sum no matter how large. On the contrary in the Hindu metaphysical view, one does not come close to God with that which He is, instead one stresses that which He is not, not body, not physic, not spirit, not intellect, he is above and beyond the Being itself. Given that any positive title acts as a restriction of His Nature, the only way to describe Him is in the use of negative epithets such as Unlimited, Infinite, Immeasurable, Unknowable, Uncontainable, and so on. Such a theology called 'apophatic' which goes from the bottom up, always less defined and comprehensible, cannot do other than lead to a total Unknowability of the divine Essence and His total transcendence with respect to every aspect of the created, the only fundamental certainty which human beings can arrive at.

Now if in India the denial of the duality constitutes the main way to try to see that which is unseeable in itself, this same denial of the 'dual', which separates and divides, is that which best marks out the Christian tradition. The denial of the 'two' expresses itself here, however, with the affirmation of the Three, that general symbol of how much it goes beyond every possible separation. Orthodoxy, today, and therefore all of ancient Christianity,

saw in the Trinity of God the same symbol of the divine unknowability which the Indian sees as non-duality.[1] The same incomprehensibility and elusivity for India is the non-duality of Brahma, the same incomprehensibility and elusivity for us are the Trinitarian Characteristics of God, a single Nature but Three persons, an incomprehensible mystery in itself, uniquely revealed to us which is explicitly confirmed in the Scriptures, concerning the coming of the Son from the Father and of the procession of the Spirit from the Father: in this way the Unity is included in the Triplicity, and the Triplicity itself gives the Unity a structure in which the One is Three and at the same time the Three reduces to the One.

The contrast between the two ways, 'cataphatic' and 'apophatic', is clearly found around the fifth century after Christ in the treatise about mystic Theology by Dionysius the Areopagite. It is from him that, within Christianity, the categorical affirmation comes that the main way to attempt to ascend to God is the negative 'apophatic', the unbreakable premise is the unknowability of God. If God is unknowable, all that we perceive or know acts as a screen or obstacle in approaching Him. Therefore every layer, visual, sentimental, intellectual must be stripped away in order to rise up into the unknown and gradually penetrate the divine Mystery.

The best example of this is Moses climbing up Mount Sinai leaving behind the camp, the men and even the priests to penetrate alone the mysterious Unknowability of the Deity with whom he speaks but whom he does not see.

The affirmation of the 'apophatic' method, inaugurated by the writings of Dionysus, was then adopted by most of Christianity by all the important theologians, above all from the Byzantine, Sinai and Greek areas, such as Gregory of Nyssa and Gregory Palamas, to surface in the field of philosophy and mysticism in Western Christianity, from John Scottus Eriugena up to Eckhart. There can be no doubt, regarding the spiritual realization, that the ancient contemplations of India found their natural successor in early Christianity.

Moreover the analogy can be inverted. If this was thought to be an element in favour of the efficiency and the universality of Hinduism to direct man who aspires to know God, well cannot one also turn the parallel upside down, and to discern in the Hindu meditative practices an anticipation of some centuries which later will become the oldest and most authentic of Christian practice to open the road which leads to God?

[1] See V. Lossky, *Thèologie mystique de l'Eglise d'Orient*, Chapter III.

I certainly do not have the ability, beyond these inadequate words, to go deeply into the examination of what is inexpressible in itself and of which others, with much better competence, have let us glimpse some tracks.

Therefore, I believe the point has been reached which makes clear the intention of this contribution: to accentuate the essential role of man in the cosmos both from physics on the one hand and metaphysics on the other. It seems to me that such an accentuation assumes a level of importance which is different according to the perspective with which each of us sees the world.

Those who limit their interest only to the physical field can omit all of the second part of this paper and concentrate their attention on how the physical world can reveal to us the role of man.

Those who, and under whatever form, be it religious or philosophical, feel again the presence of God in the cosmos, would recognise in the present considerations that specific metaphysical vision which corresponds to their faith.

Finally whoever adheres to Christianity finds that Father, Son and Paraclete are taken for their intrinsic Reality, whose setting, within the framework we have just discussed, places them in the Unknowability of the divine Essence, and would be themselves inexpressible and elusive, had not the Person of the Son, in himself unconceivable and unreachable, for a unique event in history, wanted to become incarnate in human form. And because the uniqueness of this event breaks the line of all the other great Sent, expressions of the Divine Energies, He came to create a unique and unrepeatable fact, since He who in this manifested and revealed himself is, nevertheless, the Un-revealable and Un-manifestable Himself.

This in our opinion, is the true exceptionality of Christianity: not only the Trinitarian view, the distinction of the three Persons, Father, Son and Holy Spirit, which – not being remotely imaginable for the human mind if not through the anthropomorphic models, and thus of all unreal – is none other than an expression, as already said, of the total unknowability of the Divine Essence; but that this unknowable mystery manifested itself in a human being and therefore subject to all the events in life.

One may not accept it; but if one does accept it, then the manifestation of Christ cannot do other than differentiate it from all the other great Sent, even if nothing is taken away from the full validity of the other Revelations into which He frames in, and summarises them in Himself.

The choice, between the two options, does not happen, in my opinion, at a rational level: it is a question of internal adherence, of direct intu-

ition, of faith and therefore of environment. No one is better than another for having made a given choice; whether one adheres to a particular philosophy, or to one of the divine Energies, or whether one points directly to the Essence, it is always the climb towards God which is looked for, both by all the believers on the earth and sometimes also by those who do not directly think about it.

I have thought that, if the development and fine tuning of the situation in the various sciences constitutes the main objective of an Academy such as ours, its most refined quality of being 'pontifical' should suggest not to overlook the connections of sciences that constitute the metaphysical background on which, to my mind, even the objectivity of the world is rooted. This is why I have ventured to present this perhaps too personal contribution; although such a precise focalisation is not frequently practised, I am induced to think that its happening from time to time might not constitute, even for those with completely different views on the subject, an inadequate occasion of reflection for meetings as the present one.

A NOTE ON ASPECTS OF CLASSICAL PHYSICS IN THE TWENTIETH CENTURY

RAYMOND HIDE

Preamble

If 'culture' is the general state of intellectual development in society as a whole then 'science' is an important and distinctive component of culture. Herein must surely lie the main cultural value of science, the subject with which this meeting of the Pontifical Academy of Sciences is concerned.

A systematic way of dealing with experience, science is [1] 'the creation of the human mind, with its freely invented ideas and concepts.

– (Scientific theories) try to form a picture of reality and establish its connection with the wide world of sense impressions.

– (Thus) we find our way through a maze of observed facts, to order and understand the world of sense impressions.

– (Without) this belief in the inner harmony of the world there would be no science'.

But the scientist is no stranger to ignorance and doubt [2], 'being fully aware that scientific knowledge is a body of statements of varying degrees of certainty – some most unsure, some nearly sure, but none *absolutely* certain. Great (scientific) progress comes from a satisfactory philosophy of ignorance'.

Science swallows its past! Unlike all other forms of knowledge, scientific knowledge is such that [3] 'the insights of the past are digested and incorporated into the present in the same way that the genetic material of our ancestors is incorporated into the fabric of our body'. No person now alive [4] 'could understand Shakespearean experience better than Shakespeare (himself), whereas (within the foreseeable future) any decent eighteen-year-old student of physics will know more physics than Newton'.

Science [5] 'makes great demands on the purely cognitive side of human nature, (but) it also speaks to the affective side. To achieve a significant advance in science makes just as great a demand on the intellect, imagination and personality as does the work of creative writers, poets, painters, sculptors and composers'.

Aspects of Classical Physics

Physics is the scientific discipline that is concerned with matter and energy and their interactions. Possibly the most stupendous development ever to have occurred in science was the rise of *modern* physics in the twentieth century [6]. Less impressive though still very significant were concomitant advances in most areas of *classical* physics, which is based on laws applicable to processes on length scales and time scales where both quantum and relativistic effects are negligible.

These laws are concerned with (i) forces and their relation primarily to the motion of bodies of matter ('dynamics'), (ii) relations between heat and other (e.g. mechanical, electrical) forms of energy ('thermodynamics'), and (iii) the effects arising from the interactions of electric currents with magnets, with other currents, or with themselves ('electrodynamics').

The laws were well established by the end of the nineteenth century, but, to paraphrase a prescient warning issued by Maxwell three decades earlier at a meeting arranged to discuss the problem of free will [7], the traditional preoccupation of physicists and applied mathematicians with phenomena that are simple, stable and insensitive to boundary conditions and initial conditions had created over-confidence in the 'all-encompassing influence of the laws of Nature'. Thus, knowing that the general circulation of the gaseous atmosphere of the Earth under the influence of differential solar heating must be governed by the laws of dynamics and thermodynamics, and emboldened by the success of physicists in establishing these laws, one leading scientist when asked in the year 1900 to predict likely developments over the next half-century was rash enough to suggest that little more than routine efforts by meteorologists trained in physics and mathematics would soon lead to highly accurate weather forecasts! Evidently unaware of Maxwell's warning he clearly overlooked the serious mathematical difficulties which still beset physicists and engineers in their attempts to apply the laws to real systems [8-14].

These difficulties are especially severe in theoretical research on turbulent fluid flows and other complex processes encountered in the study of

continuous media. The governing partial differential equations in terms of which the physical laws are expressed mathematically certainly provide valuable theorems and other useful diagnostic relationships between key variables. But the essential nonlinearity of the equations makes them virtually impossible to apply directly in most prognostic work, where all the multiple solutions of the equations would have to be found and their stability thoroughly investigated.

Classical physics understandably declined in popularity as modern physics advanced, although some talented practitioners pursued fruitful careers in the subject [15]. Others kept a foot in both camps, at least to start with, including scientists of the calibre of Heisenberg whose well-known contributions to the theory of stability of parallel shear flow and turbulence in fluids [16, 15] were outshone by his great work in quantum mechanics [6]. With many new problems to be tackled in modern physics there was no strong temptation to spend time seeking explanations of natural phenomena such as the Gulf Stream in the Atlantic Ocean and the Great Red Spot in Jupiter's atmosphere. And other phenomena now investigated under the heading of 'geophysical and astrophysical fluid dynamics' such as the magnetism of the Earth and the corona of the Sun would remain enigmatic until pioneering work by Alfvén and others [17, 18] had created the new subject of 'magnetohydrodynamics' (MHD).

MHD involves the application of all the laws of classical physics, for the (pre-Maxwell) equations of electrodynamics are also needed when treating the flow of an electrically-conducting fluid. Much material in the cosmos is both fluid and electrically conducting and on the scale of cosmical systems MHD phenomena abound. But most underlying processes are impossible to reproduce on the very much smaller scale of the terrestrial laboratory, owing mainly to the difficulty with available fluids of achieving high enough values of the 'magnetic Reynolds number' $UL\mu\sigma$ (where U is a characteristic flow speed, L a typical length, μ the magnetic permeability of the fluid and σ its electrical conductivity). Significantly, this obstacle to progress is now being overcome to some extent by the increasing use of powerful computers for integrating the governing equations.

Computational fluid dynamicists strive for breakthroughs in understanding turbulence and other fundamental processes characteristically involving many different length scales and time scales [19]. As in laboratory studies, basic general theorems and dimensionless parameters play a central role in the formulation of crucial investigations and the interpretation and application of experimental results. Dimensionless parameters

(such as the magnetic Reynolds number) are readily identified by expressing the governing equations in dimensionless form, but their successful use is less straightforward and remains something of an art [20].

Fortunately, experience shows that it is not always necessary or even desirable to insist on complete geometric and dynamic (and, where appropriate, thermodynamic and electrodynamic) similarity. We now see, for instance, albeit with twenty-twenty hindsight, that if physicists in the late nineteenth century and early twentieth century had made simple but systematic 'curiosity-driven' laboratory investigations of flow phenomena in spinning fluids, unexpected dynamical processes, including deterministic chaos, of direct relevance in meteorology, oceanography and other areas of science and engineering would have been discovered much sooner [12]. Whilst it is impossible in the laboratory to simulate a planetary atmosphere in all its details, much of our knowledge of fully developed 'sloping convection' – a process which underlies many natural phenomena such as highly irregular waves and jet streams seen in the Earth's atmosphere and the more regular large and durable eddies in the atmospheres of the major planets – comes from laboratory experiments on thermal convection in rotating cylindrical (rather than spherical) fluid systems no more than several centimeters in size. These were eventually started half a century ago, long before computers became powerful enough to play a significant role in such research.

At the beginning of the twenty-first century we can be sure that all branches of science will continue to benefit from improving computer technology [19] and fundamental advances in mathematics [10]. But in forecasting detailed future developments scientists in the past have shown little more than modest skill [21], even with the benefit of fascinating insights provided by the imaginations of non-scientific colleagues. We can look forward to many surprises.

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