the Pontifical Academy of Sciences

Final Statement

Summary and Statement of the Plenary Session 2016 of the Pontifical Academy of Sciences with the topic “Science and Sustainability: Impacts of Scientific Knowledge and Technology on Human Society and its Environment”

Thirty-five Academicians attended the Pontifical Academy of Sciences (PAS) Plenary Session on 25-29 November 2016. Thirty-one of them contributed to the proceedings with a lecture in their scientific area of expertise. In order to enrich the program, three half-day sessions were devoted to the fields of *Cosmology*, *Energy* and *Food and Nutrition*. These special sessions were enriched by lectures delivered by seventeen invited scientists, who are not members of PAS, who were also invited to attend other sessions of the scientific program. The special session on *Cosmology* was devoted to the memory of the fiftieth anniversary of Msgr. Georges Lemaître’s death, who was PAS President from 1960 until 1966. The special session on *Energy* provided welcome insights into more sustainable sources of energy, made possible by the technological applications of acquired scientific knowledge. Similarly, the special session on *Food and Nutrition and the Role of Biotechnology in Agriculture* provided increasing knowledge on the effects on health of our daily diets and how these contribute to medical progress, an increase in human health and longer lifespans.

At the Opening Session, several Academicians recalled the importance of sustainability and our long-term responsibility to protect our varied environment. This is essential to insure appropriate living conditions for many generations of human beings within the rich diversity of living organisms and their appropriate habitats. We can expect to further benefit from increasing scientific knowledge and its responsible technological applications. Recently developed research methods offer timely possibilities to obtain novel insights into the laws of natural development. For example, they enable a better understanding of the neurological functions of higher animals and, in particular, of human beings. Neurobiologists consider their acquired knowledge as essential in the field of education, also providing long-term forecasts for maintaining appropriate living conditions for humankind in the future.

Furthermore, recently developed research methodologies also enable astrophysicists to obtain deeper insights into the tremendous size of the Universe and into the historical development and life times of solar systems with their planets. We can now expect that the search for existing planets with appropriate conditions to host living organisms may eventually lead to discovering whether life – and what kind of life – exists on distant exoplanets. Such knowledge would represent an important contribution to cosmology and to our worldview.

The scientific basis for the understanding of living organisms is their capacity both to propagate and to slowly undergo evolution at the population level. The driving force of biological evolution is the occasional occurrence of spontaneous mutagenesis in one individual of a population. Both the parental forms and their mutants are steadily submitted to Darwinian natural selection. New insights into molecular mechanisms of genetic variation revealed several natural strategies to occasionally undergo spontaneous mutagenesis and thus to contribute to biological evolution. Biological evolution does not depend on errors and accidents; the genetic

setup of living organisms enables them to autonomously undergo evolution at the level of their population. In their natural habitats living organisms mostly cohabit with other kinds of living organisms. This allows them to mutually profit from each other by symbiosis, i.e. by helping each other. A good example are the microbiomes, the cohabitation of microorganisms with eukaryotic plants and animals, including humans. We now realize that our own genome is not solely responsible for our life activities, some of which are carried out with the help of cohabiting microorganisms. Furthermore, long-term cohabitation occasionally offers the chance to transfer one or a few genes horizontally between the different kinds of organisms. Horizontal gene transfer has been identified to represent an important evolution strategy, in addition to spontaneous intragenomic genetic variation. Therefore, we do not only have a common past with other kinds of organisms, we also have a common future with cohabiting organisms.

The products of several natural barriers against viral infection and too frequent horizontal gene transfer, in particular between microorganisms, have now become used for so-called gene editing, i.e. altering particular nucleotide sequences in the genome. In principle, this can also help to repair undesirable mutants, but the application of this method should strictly respect ethical considerations.

Scientific investigations have recently revealed various sources of erroneous malformation, in particular during embryonic development. The sources include: the lack of certain essential micronutrients (hidden hunger) or viral infection, such as by the Zika virus. We strongly hope that scientists find appropriate means to prevent these kinds of unhealthy developments. Resilience has in particular become a topic in neurobiology by natural means to prevent wrong developments. Please see Appendix 1 for a more detailed summary of this Session.

Our Academy is aware of a number of largely unpredicted harmful impacts of certain human activities. An example that has been discussed again is climate change, which is based on several sources, which are rooted both in geophysical events and in human activities. The latter are of serious concern if the expanding needs of the developing world for energy, especially electric power, are supplied by the burning of fossil fuels. A further example of harmful human activity, as revealed by recent studies, is the increase in ocean contamination due to plastic pollution.

Concern was also expressed regarding the ongoing practice of organ trafficking and transplant tourism. On the other hand, our Academy was pleased to receive information on recent progress in the fight against cancer.

As previously mentioned, the increased use of renewable energy sources can significantly contribute to preventing negative environmental impacts of human activities. These sources are within reach and deserve to be promoted.

Through contributions made to the special session devoted to *Food and Nutrition and the Role of Biotechnology in Agriculture*, it has become apparent that scientific means are available and should be utilized to improve the nutritional quality of daily diets of all human beings. Appropriate scientific education, coupled with a wide respect of ethical rules, can be expected to contribute to this development. The Academicians believe that encouragement by the Church would be beneficial and would contribute to preventing malnutrition and its negative impacts on human health, from the early embryo up to old age. Relevant biotechnological innovations are known not to cause unpredictable danger. Rather, they largely follow the laws of Nature for biological evolution. Therefore, responsibly applied biotechnological methodologies can importantly contribute to improving human health and eventually also preserve the rich diversity of our habitats and their inhabitants. In the Appendix 2 you will find a summary of this Session.

Appendix 1 - Biomedicine

In the area of biomedicine it was discussed how the microbial world has cohabitated since the early stages of life. Horizontal transfer of large numbers of genes and genomes are still today being exchanged. Thus, transgenic organisms are an integral part of the microbial world which surrounds and lives inside the human body.

Potent new genome editing techniques have become available very recently. This technology known as CRISPR/Cas9 has an awesome power to direct changes to specific regions of the DNA using simply a 20-nucleotide mRNA and a bacterial nuclease called Cas9. This system, normally used by many bacteria to acquire immunity to viruses, has an enormous potential to modify crops and animals but the modification of the human germ line presents enormous dangers and is to be strictly avoided. However, CRISPR/Cas9 gene editing has potential for the treatment of human diseases in somatic tissues, such as cancer-producing DNA translocations that generate novel sequences and viruses such as HIV that integrate in subsets of immune cells.

It was also discussed how high-throughput genome sequencing is now making it possible to identify many loss-of-function mutations that affect only one copy of a gene yet can produce human malformations. These *de novo* mutations are absent from both parents and originated in their germ cells. Unexpectedly, the human genome contains hundreds, possibly thousands of genes that can cause birth defects. Congenital disease is also caused by the Zika virus epidemic that is now sweeping the world and especially Latin America, leaving in its aftermath many children with microcephaly and epilepsy. The sanctity of the life of these malformed children will have to be defended vigorously from a global secular culture that openly defends euthanasia, as was presciently foreseen by St. John Paul in the 1995 encyclical *Evangelium Vitae*, paragraph 3.

Appendix 2 – Food and Nutrition

1. Pope Francis emphasized food security and sustainability in addressing the Pontifical Academy of Science (PAS) on 28 November 2016. Poverty and extreme inequality must be overcome, because it is poor women, men, and children who suffer most from hunger and undernutrition. About 800 million people are hungry and about 2 billion suffer from so called "hidden hunger", i.e. they are deficient in micronutrients. This problem must be addressed with much more urgency, especially the Vitamin A deficiencies among children that can lead to blindness, and often death during the childhood.

2. We at PAS emphasize that science can play a key role in ending hunger and undernutrition, as indicated by the earlier PAS session on *Bread and Brain* (2013), which addressed some related themes, including the adverse long-term neurological consequences of undernutrition.

3. We took note of the food needs of present and future generations and concluded that at least approximately 50% more food production is needed by 2050. We also emphasized that not just more, but more healthy food, that is accessible and affordable by low-income people is needed. Stronger food, nutrition, and agriculture science systems that serve the poor are needed.

4. We considered various options to overcome so called "hidden hunger" (i.e. the micronutrient deficiencies of Iron, Vitamin A, Zinc, etc.) and their devastating short- and long-term health effects. Sustainable approaches are plant breeding innovations that get more micro-nutrients into the crops grown year after year, referred to as biofortification. The undernourished have no time to loose, therefore such promising approaches need to be scaled up faster and combined with other approaches to achieve fast nutrition progress, including industrial food fortification, medical supplementation, and promotion of nutrition-sensitive local agriculture and horticulture.

5. We also noted that consumption habits of the wealthy need changing. We observe, with concern, that much food is lost in production and after harvest, as well as wasted in consumption. While we need better practices to cut losses and a new respect for food to cut waste, even when waste and losses are reduced, a lot more food production is needed in the coming five decades. While redistribution of wealth between rich and poor is called for, redistribution of food is not a solution to the hunger and malnutrition problems.

6. Food and nutrition security must be in harmony with nature and the environment. We build our deliberations on the earlier PAS/PASS session on *Sustainable Humanity – Sustainable Nature* (2014). All food must be produced more sustainably with respect to soils, water, biodiversity and climate sensitivity. We benefitted from new insights about prevention of soil degradation, no-till cultivation, and precision farming.

7. We noted that genetically modified crops have in fact brought significant income benefits to the poor already, but not yet direct consumption benefits, because of regulatory barriers. We took note of promising crop-biological innovations including with genetic modifications that use less resources, produce less greenhouse gases, are higher yielding, and which have more micronutrient contents. These innovative crops should be tested at scale, and released quickly if they hold promise.

8. We are aware of widespread reservations against genetically modified crops, which is partly fostered by scary, unfounded information. The fact that GMOs are connected to some large corporations may also be fostering rejection of GMOs. As it had already been requested in 1975 at the Asilomar Conference, solid risk assessments should accompany any new technology introductions. We call for a focus on product characteristics and proven benefits. Information to the public is needed, for instance that gene transfers among organisms is part of natural evolution including the plants.At the same time research is needed to better understand the root causes of attitude and fear formation, including food fears and biotechnologies.

9. We received comprehensive information about new molecular-biological methods (including gene-edited, and genetically modified crops) that offer opportunities to facilitate increased income and better nutrition of the poor. As our Academy noted before, in 2010, solid and transparent testing including for health and environmental aspects, of context specific applications of GMOs is required, as for any crop innovations.

Regulations must be science- and evidence-based and not dominated by advocating special interest groups. It is time to revisit and appropriately use biological innovations in agriculture in support of nutrition of the poor.