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SCIENCE FOR MAN AND MAN FOR SCIENCE: THE VIEW FROM THE THIRD WORLD

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INTRODUCTION

My contribution to this meeting of the Pontifical Academy of Sciences has suffered many fluctuations. I initially received information that the general title of the Symposium was going to be the one given in the first line of this paper, which indeed suggested to me the title that I should use. I then received information that the general title had been changed to "Science and the Future of Mankind" and I was requested to make a contribution more in line with of my own specialization, which is physics. I then sent a one page abstract on "Twentieth-Century Physics and Beyond", of which I have distributed a copy.

When I made a presentation in Mexico of a first draft of this new contribution I realized that in twenty minutes I would barely be able to deal with the electron, and so I decided to go back to my original title, which caused much confusion in the Secretariat of our Academy as, initially, two proposals were distributed.

Returning to my original title I want to modify it a little. It speaks of the 'Third World' because, originally, the First included democratic nations with market economies; the Second referred to socialist countries which had chosen a different path of development; and the Third World included everybody else.

Today the socialist countries have essentially disappeared and even China, while still totalitarian, is now following a market economy. Thus I would like to make the following classification: developed countries, developing countries, and underdeveloped countries, which are likely to stay that way. I will not list by name the classification of countries, except for

my own Mexico, as I do not wish to offend anyone, but the actual title of my talk will be "Science for Man and Man for Science: The View from Developing Countries".

Due to the limitations of time and space, I will confine my presentation to a few examples, first indicating the way that science has affected men in the countries mentioned, and then speaking of men in them who have contributed to this aspect of science.

1. The Population Explosion

This subject is a sensitive one within the Pontifical Academy of Sciences, but I consider that we must tackle it if among our duties there is that of *advising* the Church on scientific matters. I underline the word 'advising' because the Academicians do not presume to dictate the course of the Church on any matter, and the Church, we hope, does not wish to dictate its viewpoint to the Academicians. The example of Galileo shows the dangers of not following such a course.

The reason that I mention this subject in my talk is that, in my opinion, nothing has contributed more to the problem of the population explosion than the great advances in medical and biological sciences which started about the middle of the nineteenth century and increased enormously during the twentieth.

There is no question that the eradication of some diseases such as small pox and the understanding of how others, such as cholera or malaria, spread, has helped to reduce the mortality rate in developing countries, while the birth rate has decreased much more slowly. In my own country, Mexico, I have seen this phenomenon during my lifetime as the population increased from 20 million in 1940 to 100 million today. Similar situations hold in most of the other developing countries.

One could argue that due to the size of most of these countries the population expansion has not been such a bad thing. The problem, though, is not so much the expansion, but the rate at which it takes places. The Mexico of the year 2000 has a much larger class of middle and rich people than in 1940, but while maybe proportionally the number of poor has diminished, in absolute numbers it has grown and the increase of facilities for work, education, housing etc., cannot keep up with the increase in population. Of course this situation is not only due to the demographic explosion because there are other causes such as corruption, exploitation, political in-fighting, etc., but nevertheless the application of scientific knowl-

edge to the health of the population of developing countries has contributed, in many of them, to bringing about an average life expectancy which is not very far from that of developed countries, while the birth rate is several times higher.

There is no question that science can also contribute to bringing about a lower birth rate in these countries, but many obstacles are in the way, on which I will not dwell as they are not of a scientific nature.

What about "man for science" in the biomedical sciences in the developing countries? In view of the gravity of the diseases that existed in these countries, in the nineteenth century they had already started to develop scientific groups to attack these health problems. It is sufficient to mention the name of the father of our former President, Carlos Chagas, to see for how long biomedical scientists in developing countries have been active. We can say that at the present time most disease prevention activity in developing countries is being carried out by local people, who probably make up the largest group of the scientific establishment in these countries.

2. Genetically Modified Products

Whereas the first half of the twentieth century witnessed its greatest development in the physical sciences, it is likely that history will consider that the second part of the century was marked more by the development of biology in its genetic aspects.

The discovery that the DNA molecule carries genetic information, and the manipulation of this and related molecules to modify the character of many living species, was one of the great triumphs of twentieth-century science, and this is likely to be even more important during the twenty-first century.

My discussion will center on the genetic modification of plants to make them more resistant to pests or to improve their characteristics for human consumption.

Time limits me to this last aspect and, in particular, to the development of rice with beta-carotene to replace normal white rice, which does not have this substance. This problem is important because rice is the main source of food for more than half of the population of the world, most of whom reside in developing countries.

Over the last few years most educated people have been exposed in newspapers, books, television, etc. to the fight going on between those who believe that genetically engineered products are fundamental for a sustain-

able and developed world and those who argue that these products need to be very thoroughly tested in order to guarantee that their use does not lead to lethal unexpected consequences.

There is some sound argument in both points of view, but what is certain is that scientists will continue to practice genetic engineering in order to more effectively understand the role of the genes of all species and, in particular, those that we are now learning about through the human genome project. Thus, as science cannot be stopped we must direct more and more effort to studying the benefits and dangers of the application of this knowledge.

In developing countries there is great interest in the advances in genetics and biology in general, and while, for economic reasons there is, as far as I know, no direct contribution to the mapping of the human genome, there is no question that in these countries there are many scientists who will be ready to make use of the new knowledge in the field as soon as it becomes available.

The number of geneticists and molecular biologists in developing countries is still small as compared with advanced countries, but they constitute an important part of the scientific establishment of those countries. It is possible that the increase in their numbers will be faster than will be the case with most of the other branches of science in the countries mentioned. This is because their eventual influence on the life of their populations is likely to be greater.

3. Nuclear Energy

This subject has developed during my lifetime because I was a member of the first generation of graduate students who entered Princeton University after the Second World War.

Several of my professors had participated in the Manhattan Project but for the most part they had taken part in developing nuclear reactors for the production of plutonium. However, they were keenly aware that their designs, with technological modifications already available in the market place, could be used to generate energy, mainly in the form of electric power.

Thus fifty years ago people were enthusiastic about the prospect of nuclear energy and considered that science and technology could solve any remaining problem.

How different from the view today! In most countries nuclear energy is a “bete noir” which they must get rid off, without there being a thought about the dangers that all other forms of energy production involve.

There is no question that nuclear energy presents dangers of which people were not fully aware fifty years ago, but in the same way that science and technology made nuclear energy possible, so can we expect that eventually they will be able to deal with these dangers.

How is nuclear energy seen in developing countries? Unfortunately, most of them have not followed the example of France, which started by improving its scientific base after the Second World War and, at the same time, by training nuclear technologists, some of them in foreign countries. As a result, France was able to develop its nuclear energy program with its own personnel who knew all the aspects of the problem including its dangers. As I recall, France now produces from nuclear reactors about 70% of its electricity needs and its safety record is commendable.

Most developing nations have not followed this path, because while physics and related sciences were developed (there were 3 Ph.Ds. in physics in Mexico in 1950, and they are about 1,000 now, which is still a very small number for a population of 100 million) they had little influence on the advance of the nuclear program. Most developing nations bought nuclear reactors and trained the personnel that was going to operate them in developed countries. Thus they do not have a full understanding of the processes that France, for example, has. In any case, nuclear energy contributes only a small part of the electric power that is required in developing countries.

We must remember that while producing energy from coal or oil in the form of fire can be done by almost anybody, nuclear energy is the result of extensive scientific and technological inquiry. Thus, developing nations must increase their human infrastructure in the sciences and technology that underlie nuclear power. In view of the dangers of fossil fuels (earth warming, air and water pollution, etc.) I believe that the nuclear energy option will continue to be considered in the future, either in the form of safer fission reactors or, eventually, through their substitution by fusion reactors.

4. The Electron

The two most basic contributions of physics during the twentieth century, both to science and modern living, were probably the electrons and quanta, which are symbolized by the letters e and $\hbar$.

Time restrictions allow me only to deal with e in the last section of this paper. While the final discovery of the electron was attributed to Thompson

in 1897, there is no question that the full understanding of its impact on all aspects of human life took place in the twentieth century.

In this paper I cannot go into the appearance of the electron in deep problems of physics, going from solid state to elementary particles. I will concentrate, instead, on two practical applications: television and computers.

There is no question that without electrons television screens would remain blank and we would not even be able to generate the electro-magnetic waves that carry information to them.

Science and technology were absolutely essential for the development of the television. It is a shame, though, that this very major invention is mainly used for advertising or the transmission of stupefying programs. This, however, is a problem that affects equally the three types of nations of the world: the developed, the developing and the undeveloped. Discussion about it is not appropriate in a paper dealing only with the view from the developing world.

The computer is another matter. It may be the biggest technological revolution that took place in the twentieth century, and it is now affecting all the people of the world.

In the developing world, the influence of the computer is ambivalent. On the one hand, it appears everywhere in all the parts of the societies of developed countries, ranging from research institutions to restaurants. On the other hand, I can give the example of Mexico, in which a recent statistic mentions that 52% of the population has never made a telephone call. For these people, for whom a phone seems to be a magic invention, the computer lies completely beyond their understanding.

The impact of globalization, felt throughout the world, requires eventually that every single human being should be computer-proficient or, at least, have direct access to individuals with this knowledge. In developing countries, the more advanced part of the young population has made computing science and business administration the two most popular fields of the curriculum in all institutions of higher learning. On the other hand, the more retarded part barely finishes primary school and has a rudimentary knowledge of reading, writing and arithmetic.

The computer has given to man an extraordinary product of the development of science, particularly in its mathematical and physical branches. In the developing countries the men that can make full use of this product, and even contribute to its further development, must become aware of what its effect is on the other half of the society in which they live, If they

do not invest part of their time in making the majority of their population computer-literate, they risk creating a cleavage that may create unbalance in their countries.

Conclusion

I have tried to show in this paper – through the use of a few examples – what science has done for man in developing countries, both in positive and negative terms. I have also tried to show that the men engaged in science in these countries, who are still very few when compared to those in the developed world, should struggle to increase their numbers and then not only contribute to the international development of science but also fight to ensure that these developments do more benefit than damage to the countries in which they live.