IN PRAISE OF TECHNOLOGY'S HUMANITY

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When I received Dr. Vlavianos-Arvanitis' kind invitation to prepare a paper on science and technology for an international conference on "Bios in the Next Millennium", I was really puzzled. Like most people, I thought "next millennium" meant the next one thousand years. As Niels Bohr said, "it is very difficult to make predictions, especially about the future", so, I hesitate to express any opinions about the course of science and technology in the next millennium. I was ready to decline the privilege and opportunity to participate until I consulted my Webster's New Collegiate Dictionary, 1961 Edition. To my great surprise and amusement, I learned that the word "millennium" has at least three meanings:

mil-len'ni-um:

1. A thousand years; also, a thousandth anniversary; a millenary.
2. Specif., the thousand years mentioned in Revelation XX, during which holiness is to be triumphant. Some believe that during this period Christ will reign on earth.
3. Hence, a period of great happiness, good government, freedom from wickedness, etc..

The third meaning delighted me, and made me especially happy to accept the invitation. For I believe that science and technology do provide the means to render our lives happier, well governed, free from wickedness, etc..

Science and technology are not materialistic pursuits. They are humanizing activities. They serve the noblest interests of mankind in the most humane manner. They provide a powerful means to achieve a society free of hunger, illness, illiteracy, and misery.

Science and technology should not be confused with the criteria which must be used and the decisions which must be made about the direction society should follow. Once criteria are adopted and decisions are made, however, the only means that we have to reach our goals are science and technology.

To illustrate this thesis, I made some arbitrary choices and collected some statistics. To be sure, the statistics are not all-encompassing, and may not represent the most appropriate information. Nevertheless, they are revealing.

An interesting index is the gross national product (GNP) per capita. In general, the higher the GNP per capita, the wider the use of science and technology, the more productive the country, and the more humane the society. Two countries from each of the six continents are listed in Table 1. In each continent, one country has the highest GNP per capita, and the other the lowest. For example, in Asia in 1984, Japan had a GNP of $10,400 per capita, and Bangladesh $130 per capita. Again, in North America in 1984, the United States had a GNP of $15,500 per capita, and Haiti $320 per capita. We see from the table that the figures vary over a wide range, and we know very well that so do the conditions of life.

TABLE I
Gross National Product Per Capita
(US$ 1984)

GABON	3,500	JAPAN	10,400
ETHIOPIA	110	BANGLADESH	130
UNITED STATES	15,500	SWITZERLAND	16,000
HAITI	320	PORTUGAL	2,000
VENEZUELA	3,220	AUSTRALIA	12,000
BOLIVIA	410	PAPUA N.G.	760

Many humanitarian characteristics correlate very strongly with the GNP per capita. For example, years of male life expectancy at birth (Table II). Similar results apply to the female population. Availability of health care as measured by the population per physician (Table III). The degree of education as measured by those enrolled in schools (Table IV), and energy consumption per capita (Table V).

TABLE II

Life Expectancy at Birth (1984)
(Male)

GABON	--	JAPAN	75
ETHIOPIA	43	BANGLADESH	50
UNITED STATES	72	SWITZERLAND	73
HAITI	53	PORTUGAL	71
VENEZUELA	66	AUSTRALIA	73
BOLIVIA	51	PAPUA N.G.	51

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TABLE III

Population per Physician (1981)

GABON	---	JAPAN	740
ETHIOPIA	88,000	BANGLADESH	9,000
UNITED STATES	500	SWITZERLAND	390
HAITI	13,000	PORTUGAL	450
VENEZUELA	930	AUSTRALIA	500
BOLIVIA	1,950	PAPUA N.G.	16,000

It is abundantly clear from these tables that the more widespread the use of science and technology, the longer, healthier, intellectually more rewarding, and more comfortable our lives are. In short, science and technology provide the means for an equitable and humane society.

The large gap that exists between developed and developing nations has created intense and richly deserved aspirations of developing countries to enjoy the great challenges of our times. The only means known are scientific and technical; no other effective and humane way has been suggested so far.

Occasionally, especially in developed nations, we tend to undervalue the importance of scientific and technical progress. We fear that our progress may be more harmful than beneficial. Perhaps, this is in store for the immediate future. Up to this time, the benefits clearly outweigh the costs. Two simple examples are indicative. From 1940 to 1982, the averagelife expectancy at the age of 40 has increased in the United States from 31 years to 37.2 years (Table VI). This is a considerable increase and has been achieved in an environment of innumerable and ever-increasing scientific and technical activities.

TABLE IV

Education (1983)

Number Enrolled as Percent of Age Group

	SCHOOL		
	PRIMARY	SECONDARY	HIGHER
GABON	---	--	--
ETHIOPIA	46	13	1
UNITED STATES	100	96	56
HAITI	69	13	1
VENEZUELA	105	43	22
BOLIVIA	87	35	16
JAPAN	100	94	30
BANGLADESH	62	19	4
SWITZERLAND	87	37	23
PORTUGAL	122	43	11
AUSTRALIA	105	92	26
PAPUA N.G.	61	11	2

TABLE V

1984 Energy Consumption Per Capita
(GJ)

GABON	33	JAPAN	100
ETHIOPIA	---	BANGLADESH	2
UNITED STATES	280	SWITZERLAND	110
HAITI	2	PORTUGAL	38
VENEZUELA	96	AUSTRALIA	180
BOLIVIA	10	PAPUA N.G.	9

TABLE VI Average Life Expectancy at Age 40 (In Years)	
1940	31.0
1960	33.8
1980	36.7
1982	37.2

Again, in the United States in 1910 there were 85 deaths from all accidents per 100,000 population, but by 1980 the number was reduced to 47 (Table VII). The reduction occurred despite the enormous increase of activities and the complexity of life in a technology-dominated society.

Paradoxically, though it has been responsive to human needs, our progress has not been devoid of serious negative impacts and life-threatening risks, some current, and some forthcoming, both real and imagined. The list is long. It includes population growth, nuclear holocaust, transformation of the atmosphere into a greenhouse, the pollution of air, water, and land, food shortages, and fast depletion of non-renewable resources.

TABLE VII Annual Deaths From All Accidents In The United States Per 100,000 Population	
1910	85
1950	61
1960	52
1970	56
1980	47

The issues raised by the negative impacts and life-threatening risks are profound, complicated, and far-reaching. Without any doubt their resolution requires immediate and thoughtful consideration, and much more effective actions than have been our practices till now. In this respect the Biopolitics International Organisation holds the promise of making important contributions. Before concluding, I wish to comment briefly on three topics: the causal relations between everyday activities and the environment, education, and energy services.

The topic of the cause and effect relations between everyday activities and the environment was raised during the first session at this conference. In my view, whatever the impact on the environment, we are the cause - each one of us. We, the people, who devour agricultural products, who live in well-lit and well-heated comfortably air-conditioned homes; who travel in aeroplanes, ocean liners and automobiles, and who consume the manufactured goods, are responsible. So the first and most important corrective action must come from us. Without the participation of each individual, of each family, I am doubtful that any solution to environmental problems will ever be found.

A point that cannot be overemphasized is that the major responsibility for an effective response lies primarily with individuals living in developed countries. They are the principal contributors to the environmental burden, and they must set the example for its relief. We cannot expect, nor should we expect, people who are desperately trying to share small fraction of the advantages and benefits of development to remain where they are now, so that we, in developed nations, may continue our wasteful and environmentally burdensome habits. An important adjustment that developing nations must make, however, is in planned parenthood and population growth.

Education is hopefully, but not assuredly, the tool we must use to raise the consciousness of all citizens about the fragility of our environment. In this repect, I would like to share with you some of the steps taken at the Massachusetts Institute of Technology (MIT). Over the past several decades, MIT has initiated several programs on environmental engineering and science, technology and society. More recently, it has recognized that the relationship between science and society is by no means unidirectional. The development of science and technology is both influenced and constrained by political and social forces which may fall outside the domain of technocratic expertise. For these reasons, MIT believes that all students should have the opportunity to consider critical questions about the interplay between science and technology and the social, cultural, environmental, and economic contexts in which new scientific knowledge and technological applications are pursued. To that end, academic experiences about the Human Contexts of Science and Technology (Context Subjects) are being developed by teams of faculty members from different disciplines. These experiences are designed to address one or more of the following three objectives:
- To help make students more conscious of the significant commonalities which link the study of science and engineering with other branches of knowledge.
- To increase understanding of non-scientific and non-technological components of work in science and engineering. This objective may be accomplished by stressing the political, economic, and managerial considerations integral to scientific and technological projects, or the social consequences of scientific and technical developments.
- To encourage students to be more reflective about the social implications of individual actions, and to motivate discussion of other personal issues, such as avoiding intellectual "burn-out".

The residential, commercial, transportation, and manufacturing energy services needed by developed countries, and aspired to by developing societies, are essential to social progress. Today, we are satisfied primarily by consumption of non-renewable and exhaustible resources such as oil, natural gas, and coal. This consumption is extremely inefficient. If we apply the laws of thermodynamics correctly, we find that the average efficiency of energy utilization is about 10 percent in an industrialized nation, and even lower in a developing one. From the engineering standpoint, this is very low efficiency, and the theoretical potential for improvement is enormous. Of course, energy end-use efficiency will never approach 100 percent for real processes and devices, even in the remote future. The present low average value emphasizes the opportunity for large savings, and no fundamental scientific barriers exist to prevent substantial improvements. For example, changing the average efficiency from 10 to 20 percent, not an unreasonable goal over the next few decades, would reduce the energy consumption by one half without affecting energy services.

It turns out that the technical and economic factors are also favorable for substantial improvements. There exists today a broad spectrum of proven energy-saving technologies that can be employed in all sectors of society with attractive economic payback.

The shift toward greater and cost-effective energy efficiency has already begun to show sizeable results. In the United States, for example, from 1974 to 1986, the production of goods and services increased by more than 35 percent, and yet the total energy consumption remained almost flat. Analogous cost-effective energy savings have been achieved in other nations. I am confident that these trends will continue as they most certainly must.

Improvement of the end-use energy efficiency is a very important but only partial response to securing economic, environmentally benign, and safe energy services. We must address the problem of developing an entirely new energy source. The principal resources we are currently using are exhaustible and, sooner or later, we will be unable to afford them. The crucial time is decades away, and not eons or millennia from now. We must develop a major new source of energy. Unfortunately the choices are very limited, namely two: solar energy and nuclear energy.

Solar energy is on the way to resolving its problems but not yet there. The problems are primarily economic. We spend a lot of money to capture solar energy and transform it into electricity. This expenditure is not due to ordinary materials, such as steel, aluminum, copper, and glass, which are very inexpensive. However, the cost of solar installations is 40 to 50 times more than we can afford. Reducing it is an extremely difficult, if not impossible, task.

Nuclear energy has problems we are all aware of, and some, perhaps, unknown. I do not wish to point out all its advantages and disadvantages. In order to stimulate thinking, and be as provocative as I possibly can, however, I would like to conclude by stating that: nuclear power is the most economical, environmentally most benign, and safest major source of energy that we know today, including solar electricity.

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