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Some Reflections on Science in the Low-Income Economies

by

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Preface

Roald Hoffmann was born in Poland in 1937 and spent most of the first twelve years of his life in refugee camps or in hiding, until his family emigrated to the US in 1949. He did most of his graduate studies in chemistry at Harvard but spent one year as an exchange student in Moscow, USSR. After receiving his Ph.D. in 1962 he concentrated on the field of applied theoretical organic chemistry, and derived in 1965, together with R. B. Woodward, quantum mechanical rules for chemical reactions. These rules are today known by most undergraduate chemistry students. In 1981, Roald Hoffmann's work on chemical reactions was rewarded with the Nobel Prize in Chemistry, which he shared with K. Fukui from Japan.

For many years, Roald Hoffmann has taken a strong interest in the interphase of science with other fields, particularly the arts. The role of science in developing countries is also an area that he has dealt with through his work and travels. In early 1992, the Bank's Science Group asked him to present his thoughts on the subject in a lecture which gathered the largest audience the Science Group so far has seen. In this paper, which covers the material presented in the lecture, Roald Hoffmann discusses the role of science in history and in different parts of the World, especially the Developing World. Based on his own experience, which is not as limited as he suggests, he proposes a number of initiatives which may help developing countries benefit from the immense development opportunities, that in our times are offered by science. Based on this survey, he deplores the minimal attention given to science by some international organizations, including the World Bank.

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Several Worlds?

It is, in the end, as it was in the beginning, only one world. While it may useful, pragmatically, to partition this blue, green and beige globe into regions which share roughly common degrees of development, everything operates to defeat the significance of such groupings. First, there is the uniqueness of the human condition. The vagaries of evolution produce a people (usually peoples, contending for the same small piece of tillable land), a language (dialects dividing them), a culture (cultures). Beer and bargaining are there around the world, but the local brew tastes different, and the way I buy a rug is surrounded by a different protocol of niceties with the dealer in the markets of Jerusalem, Moscow and Montevideo. Every "third-world" country is different: the way things don't work in it, and the way things do, are distinct.

At the same time, the very success of modern technology operates to defeat the assignment of distinguishing features to economic systems or to countries of vastly different gross national products. The air is filled with the same electromagnetic radiation. The high standards and low problems of the affluent societies penetrate via radio and television, via print, into the most isolated crannies of the poorer countries. It is possible for an unscrupulous American company to sell for a while a contaminated fertilizer in country Y, but it is impossible to keep the concerns of a European community about antibiotics or growth factors in animal husbandry from reaching the ears of the people of Y who are in charge of agriculture, and who have often been educated in Europe.

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*The material in this paper was presented, in somewhat different form, in a lecture at the World Bank. I am grateful to Dale Corson and Dotsevi Sogah for their comments on this work, and especially to Erik Thulstrup for encouraging me to think about this material.

So, diverse in the extreme, fated by the workings of evolution to be such, the world is uniquely many. And it is one. Which is no excuse for immobility in the face of natural or man-made disasters, of great suffering and a growing economic gap between people.

Science

What is the role of science in this world? Science is a Western European social invention. Together with technology, it has transformed this world. Science is a remarkably successful system for acquiring reliable knowledge (not truth, which has an ethical connotation), for harnessing the mental and physical energies of fallible individuals to understand and change part--not all, only part--of our condition.

Scientific invention, be it the wheel and the making of aspirin, is transplantable anywhere. But its origins are European. Technologies and protochemistries developed everywhere where human beings dealt with survival and aspired to comfort. The achievements of Chinese chemists and the metalsmiths of Benin or the Andes, the skills of Mediterranean dyers, were great. But science as such evolved in 1500-1800 in Europe, and nowhere else. Chinese chemists had incredible successes in the formulation of inks, in metallurgy, and native medicine, but in the end Chinese chemistry could not free itself from its alchemical steering force.

It took the fluid economies of Europe, enriched by colonialism, the contentious ethic of striving religions, the scholarly revival of classical knowledge, the beginnings of social mobility, and the invention of movable type to put into place, ever so slowly, a way of knowing that became science.

In our times, some popularizers of science (authors of books such as "The Tao of Physics") have claimed that there are other ways of knowing, and that science is halfway to Eastern philosophy. While I concur with the first part of this claim, that science is only one culturally-bound way to know this world, I think the second part is just an affectation, arising from wishful thinking and a confusion of the whole of science with the occasionally esoteric philosophical consequences of one particular field, theoretical physics. Every talented Oriental scientist I know, even those steeped in their own philosophical traditions, when he or she has practiced science successfully, has practiced it in the Western mode.

There have been legitimate critics of science from the feminist side, pointing out to us the aggressive, male nature of the enterprise. The 19th century banner phrase describing our supposed aim, "to unveil the secrets of nature", is revealing. One may think (I actually do so) that the way of doing science should change, that supposedly female traits of cooperativeness, of sensitivity to the environment, should enter the ideology of science. But there is no taking away that what has worked, no more or less male-dominated than any other part of society, is traditional European science.

It has been argued (see for instance Sagasti, 1980, 1983) that the future of the world must involve an "advance towards a 'third civilization' in which the achievements of modern science could be integrated in a harmonious fashion with the cultural heritage of non-Western societies." I vacillate between an idealism that concurs with this outlook (and seeks to implement it, see below) and a realism, based on historical precedent, for the inability of ideals to stand up to technological pressures.

The Democratizing Nature of Chemistry

Science and technology do function. They have transformed this world, mostly for the good. With some ill consequences. While supposedly ethically neutral, the effects of science are inevitably democratizing.

The world that my great-grandparents were born into 150 years ago in the Austro-Hungarian province of Galicia, the world of the backwaters of Zaire today, was not a romantic paradise. It was, and for so many today it remains, a brutish, inimical environment. Perhaps one lived in balance with it, but with a life span far from biblical. One only has to look at the cemeteries of the last century, or read the heart-breaking diaries of our ancestors, to see the tragedy of seven children out of eleven dead before puberty, of child-birth a killing prospect. When I hear an opponent of technology speak against modern, chemically-intensive agriculture or pharmaceutical therapy, my heart beats quicker in a rush of anger at the implicit lack of simple human sympathy in his or her stance.

A doubling of our life span, less death and suffering, a greater color palette to lift the spirit, freedom from the smell of sewage, a way to cure much, not nearly all, disease; air, light, food for all; food for the soul in the Ramayana on the screen or a Mozart rondo in the air--these are things of which scientists and engineers really can be proud.

Technology and science also serve the evil side of man, as the elements of subjugation, propaganda and even torture. Some would see in this the ethical neutrality of science, and even a reason to condemn it. Quite aside from the misuses of science, to many in the low-income economies science may appear as a luxury of the elite, or just another element by which the privileged classes hold down poor people.[1] But I really do think that the overall effect of science is inexorably democratizing, in the deepest sense of the word--making available to a wider range of people the necessities and comforts that in a previous age were reserved for a privileged elite.

Chemical Industry

Here is a chart of the top ten hits of the chemical world (Table 1). These are the chemicals produced in greatest amounts in the US in 1991 (Chemical and Engineering News, 1991)

Table 1: The Top Ten Chemicals, by the Amount Produced in USA in 1990

	Chemical	Amount Produced (billions of lb)
1.	Sulfuric acid	88.6
2.	Nitrogen	57.3
3.	Oxygen	39.0
4.	Ethylene	37.5
5.	Lime	34.8
6.	Ammonia	33.9
7.	Phosphoric acid	24.4
8.	Sodium hydroxide	23.4
9.	Propylene	22.1
10.	Chlorine	21.9

Number 1, produced in perhaps 200 billion pounds world-wide, is sulfuric acid. Not on the shelves of your supermarket, it is intimately involved in almost every industrial

[1] I am grateful to Barbara Lynch for making this point to me.