Single-Cell Protein II

Tannenbaum and Wang, editors

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SINGLE-CELL PROTEIN II

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In 1967 the first international meeting convened specifically to discuss the prospects of the direct use of microorganisms as food at the Massachusetts Institute of Technology. A book based upon the papers of the conference was published by MIT Press in 1968. It was also at that time and in connection with the conference that the generic term, Single-Cell Protein (SCP) was coined to replace the supposedly less aesthetic "microbial protein."

In 1967 only British Petroleum had advanced its project sufficiently to be willing to discuss its prospects publicly. It follows that many of the papers in the first conference discuss theory rather than practice. Only five years later, in 1972, when it was decided to reconvene the conference, the problem of the organizers was how to select among the many industrial groups and processes ranging from growth of yeast on purified hydrocarbons to mixed cultures on cellulose and lignin. In that five-year period, the concept of SCP had been transformed into a fact, and, even though no full-size plants were yet in operation, it was clear that before the end of the 70s many hundreds of thousands of tons of industrially produced protein would go into animal feeds and perhaps even human food.

There are many people who are to be thanked for the success of the 1973 conference and for the publication of this volume. The conference organizing committee included Arthur Humphrey and Nevin Scrimshaw as well as the editors of this volume. The financial support for the project came from the Alfred P. Sloan Foundation, Ranks Hovis McDougall, Ltd., through Professor Arnold Spicer, and from the International Biological Program.

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Steven R. Tannenbaum
Daniel I. C. Wang
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PRODUCT OUTLOOK AND TECHNICAL FEASIBILITY OF SCP

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It was six years ago that the first Single-Cell Protein (SCP) Conference was held at Massachusetts Institute of Technology. At that time, concern was with the technical feasibility of SCP. Discussions centered around problems of economy, consumer acceptance, and toxicology. Since then the issue of technical feasibility has been resolved. Various companies such as British Petroleum; Ranks Hovis McDougall, Ltd., etc., have shown that pilot- and plant-scale production of SCP is feasible. Also, an increasing demand for protein and recent high prices of fish meal and soy meal have shown that there is and will be a market for SCP. Large-scale feeding trials have demonstrated that problems of acceptance and toxicity can be overcome with care and special processing.

It seems, therefore, that the issues of economy, consumer acceptance, and toxicology should now be resolved so that the practical realization of SCP can move rapidly ahead. In the discussion to follow, the various technical alternatives for SCP production and some of the operational and economic aspects of the various alternatives will be discussed.

In passing, note should be made of the February 8, 1972 United Nations report of the 2nd Meeting of the PAG *ad hoc* Working Group on SCP (Document 3.14/15) where the commercial and semi-commercial scale of SCP production were acknowledged. The report warned, however, that the toxicological problems with the use of SCP both in animal and human feeding still had not been sufficiently resolved to ensure fixing of the process design. This warning still applies to present SCP process designs (Chemical Engineering News 1973; European Chemical News 1973). It is not possible, therefore, to have complete confidence in economic data based on an optimal scale of operation. However, it is anticipated that toxicology tests have proceeded to the point where several different SCP process designs can now be fixed with some confidence in the efficacy of the product.

SCP Substrates

There are many possible substrates that can be used for SCP production (Board for Microbiology Industry 1971; Brand 1973). These are illustrated in Table I. They fall into three categories: materials that have a high value as a source of energy or are derived from such materials; materials that are essentially waste and should be recycled back into the ecosystem by some minimal nonpolluting means; and materials that can be derived from plants and hence are a renewable resource. SCP substrates have been classified in this manner to illustrate that resources as well as financial economy must be considered in SCP substrate alternatives. Also, the ever-increasing concern over environmental pollution has resulted in greater negative cost values of wastes and hence has increased their potential as SCP substrates.

The emerging world energy consumption pattern is shown in Figure 1. World energy consumption is expected to double between 1970 and 1980 increasing from the equivalent of 100 million barrels per day to 170 million barrels per day (Shell 1973). By the year 2000, it is projected to increase fourfold, reaching the equivalent of over 400 million barrels daily. The utilization of future resources to supply energy for the U.S. is illustrated in Figure 2. Over 60 percent will come from oil. By 1990 it is projected that imports will account for about two-thirds of U.S. oil needs. The pattern is much the same for other developed nations. However, 70 percent of the world's crude oil reserves are held by six Arabian countries. The implications of this were pointed out in a New York Times article on May 20, 1973 entitled "Oil as a Political Weapon." Obviously, the energy crisis will have an important long-term impact on SCP

Table I. Possible Substrate for SCP

Substrate	Classification
Natural Gas	Energy Source Material
n-Alkanes	" " "
Gas-Oil	" " "
Methanol	" " "
Ethanol	" " "
Acetic Acid	Energy Source or Waste Material
Bagasse	Waste Material
Citrus Waste	" "
Whey	" "
Sulfite Waste Liquor	" "
Molasses	" "
Animal Manure	" "
Sewage	" "
Carbon Dioxide	Waste or Renewable Source Material
Starch	Renewable Source Material
Sugar	" " "
Cellulose	" " "

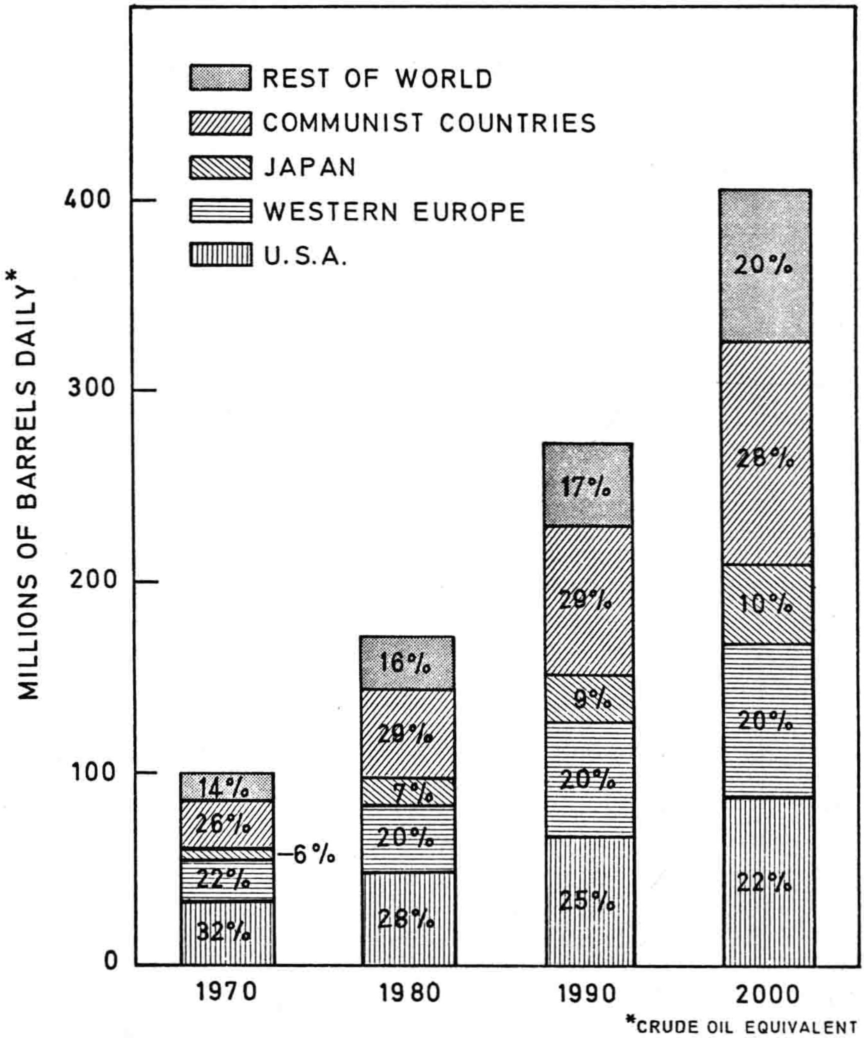

Figure 1. World energy consumption.

production alternatives.

However, the problem of energy doesn't stop with oil. There is the question of utilization of wastes and of the renewable plant resources.

Last year approximately one billion tons of solid organic wastes were generated in the U.S. (Steffgen 1972). (See Table II.) Of this waste nearly 200 million tons came from animal manure. It has been estimated that nearly one million barrels per day of oil could be obtained from this waste by a chemical CO reduction process (Friedman et al. 1972). Similarly, it has been estimated that perhaps 50 million tons per year of SCP could be derived from the manure wastes. (See Table III.) Which will it be?

With respect to this latter problem, large feed lots for cattle are posing great pollution difficulties. Feed lots handling from 10,000 to 100,000 head of cattle are becoming popular. The trend has been towards mass production. The accumulation of manure from a 100,000-head feed lot is roughly equivalent to the municipal sewage disposal problem for a city of one million people. With the development of liquid ammonium fertilizers, feed lot manure is no longer an efficient or economical manner of fertilization. Hence, manure is now stacked and is becoming a significant source of pollution in certain areas. How will the manure pollution problem be handled? Will it be turned into energy or SCP?

Complicating all these considerations is the problem of fish meal and soy meal as a source of protein. Fish meal production depends to a great measure upon the catch of anchovies off the coast of Chile and Peru. For the last two years the catches have been greatly reduced due to anomalies in the Japanese current behavior. This has caused an escalation of protein prices (See Figure 3) to create a situation where fish meal has reached \$400 per ton and soy meal \$260 per ton. These prices of fish and soy meal are equivalent to 31¢ per pound for fish protein and 30¢ per pound for soy protein.

In passing, it should be noted that the price of

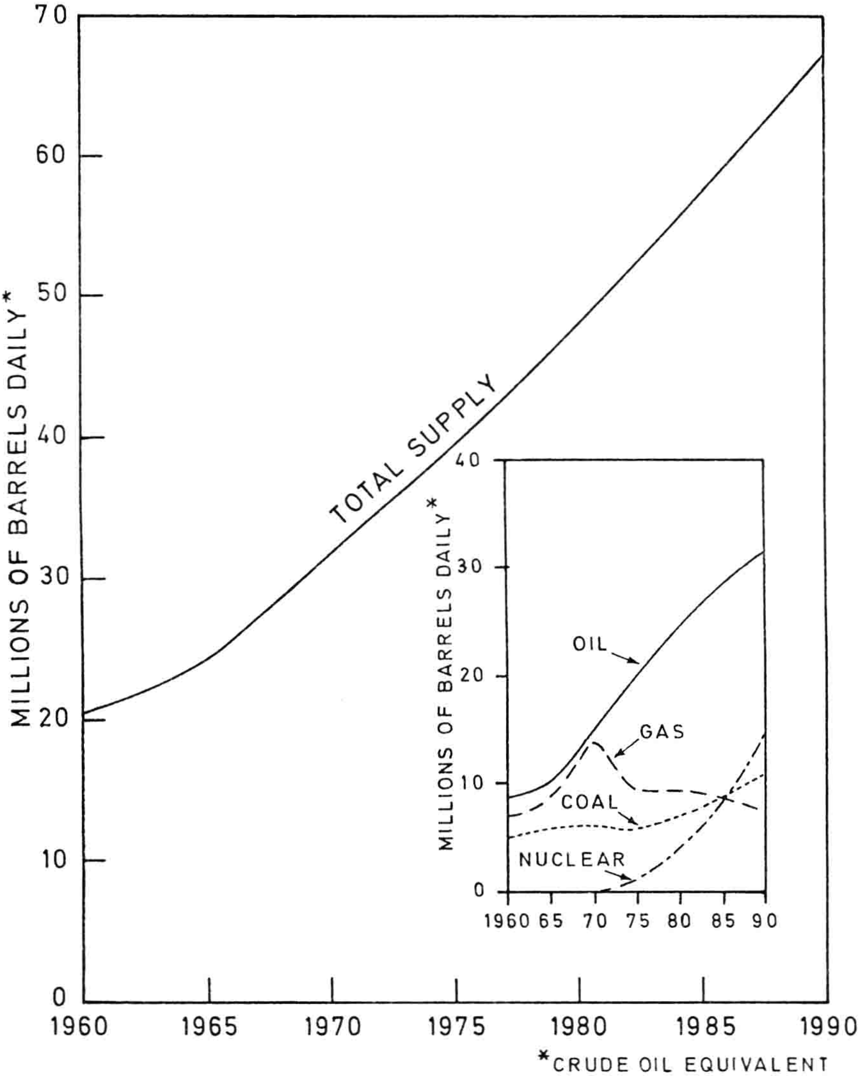

Figure 2. U.S. energy supply.

Table II. U.S. Solid Wastes

Waste Type	10^6 Tons/Year
Agricultural And Food Wastes	400
Manure	200
Urban Refuse	150
Logging And Other Wood Wastes	60
Industrial Wastes	45
Municipal Sewage Solids	15
Miscellaneous Organic Wastes	70
	Total 940

Table III. SCP Costs For A Plant Producing 30,000 To 50,000 Ton/Year 60% Crude Protein Product

	$/Ton
Operating Costs	100 ± 20
Capital Costs (7 Year Payout)	100 ± 50
Total Costs	200 ± 70

SCP has been estimated to be between $130 to $270 per ton depending upon the plant size and substrate used for SCP production. (See Table IV.) This is equivalent to 11 to 23¢ per pound of crude protein. It would seem that even at the higher costs SCP could have been profitably produced in recent months.

The significance of high soy meal prices can be illustrated by the fact that the U.S. produces nearly 40 million tons per year of oil seed meal. Roughly one-third of this is exported. At $260 per ton this produces an export income of nearly $4 billion for the U.S. This is roughly the present annual cost of U.S. oil imports.

Society seems to be heading toward a world community of energy and protein imperialists where