Lectures in Physics 1922–1941 (Elsevier, Amsterdam), p. 98.
20. H. W. B. Skinner and E. T. S. Appleyard, *Proc. Roy. Soc. London Ser. A* **117**, 224 (1928).
21. A. Kastler, *J. Phys.* **11**, 255 (1950).
22. H. G. Robinson, E. S. Ensberg, H. G. Dehmelt, *Bull. Amer. Phys. Soc.* **3**, 9 (1958).
23. J. Margerie, *Compt. Rend.* **241**, 865 (1955); P. Bender, thesis, Princeton University (1956); F. Hartmann, M. Rambosson, J. Brossel, A. Kastler, *Compt. Rend.* **246**, 1522 (1958).
24. C. Cohen-Tannoudji, J. Brossel, A. Kastler, *Compt. Rend.* **245**, 1027 (1957).
25. M. Arditi, thesis, *Ann. Phys.* **5**, 973 (1960); C. S. F., Compagnie Générale de Télégraphie sans Fil (79 Bd Haussmann, Paris 8e) Notice No. 1602 (1964); L. Malnar and J. P. Mosnier, *Annales de Radioélectricité* **16**, No. 63 (1961); P. L. Bender, in *Proceedings of the 9th Ampère Colloquium, Pisa, 1960*, p. 621; A. L. Bloom, *Appl. Opt.* **1**, 61 (1962).
26. J. Brossel, thesis, *Ann. Phys.* **7**, 622 (1952); ——— and F. Bitter, *Phys. Rev.* **86**, 308 (1952).
27. J. E. Blamont, thesis, *Ann. Phys.* **2**, 551 (1957).
28. N. Rollet, J. Brossel, A. Kastler, *Compt. Rend.* **242**, 240 (1956).
29. M. A. Guiochon, J. E. Blamont, J. Brossel, *ibid.* **243**, 1859 (1956); *J. Phys.* **18**, 99 (1957).
30. J.-P. Barrat, thesis, *J. Phys.* **20**, 541, 633, 657 (1959).
31. ———, *Proc. Roy. Soc. London Ser. A* **263**, 371 (1961).
32. C. Cohen-Tannoudji in *Quantum Electronics II* (Columbia Univ. Press, New York, 1961), p. 114.
33. J. C. Pebay-Peyroula, thesis, *J. Phys.* **20**, 669, 721 (1959).
34. P. A. Franken, *Phys. Rev.* **121**, 508 (1961).
35. J. P. Descoubes, *Compt. Rend.* **259**, 327, 3733 (1964) and **261**, 916 (1965); thesis, to be published.
36. J. Brossel, A. Kastler, J. M. Winter, *J. Phys.* **13**, 668 (1952).
37. J. Brossel, B. Cagnac, A. Kastler, *Compt. Rend.* **237**, 984 (1953); *J. Phys.* **15**, 6 (1954).
38. J. M. Winter, thesis, *Ann. Phys.* **4**, 745 (1959).
39. H. G. Dehmelt, *Phys. Rev.* **109**, 381 (1958).
40. P. A. Franken, R. Sands, J. Hobart, *Phys. Rev. Lett.* **1**, 316 (1958); R. Novick and H. E. Peters, *ibid.*, pp. 54, 152.
41. M. A. Bouchiat, thesis, *Publications Scientifiques du Ministère de l'Air* (1965), N. T. 146; M. A. Bouchiat and J. Brossel, *Phys. Rev.* **147**, 41 (1966).
42. F. Bitter, R. F. Lacey, B. Richter, *Rev. Mod. Phys.* **25**, 174 (1953).
43. B. Cagnac, thesis, *Ann. Phys.* **6**, 467 (1960); J. C. Lehmann and R. Barbé, *Compt. Rend.* **257**, 3152 (1963).
44. W. Franzen, *Phys. Rev.* **115**, 850 (1959).
45. C. Cohen-Tannoudji, *J. Phys.* **24**, 653 (1963); ——— and J. Brossel, **258**, 624 (1966); J. C. Lehmann and J. Brossel, *ibid.* **262**, 624 (1966).
46. J. C. Lehmann, thesis, Paris (1966), to be published; J. C. Lehmann and J. Brossel, *Compt. Rend.* **258**, 869 (1964); M. Leduc and J. C. Lehmann, *ibid.* **262**, 736 (1966).
47. J. C. Lehmann, *J. Phys.* **25**, 809 (1964).
48. A. Omont, *ibid.* **26**, 26 (1965); J. P. Faroux and J. Brossel, *Compt. Rend.* **261**, 3092 (1965) and **262**, 41 (1966); J. P. Faroux, *ibid.* **262**, 1385 (1966).
49. F. Grossetête, *J. Phys.* **25**, 383 (1964); *Compt. Rend.* **259**, 3211 (1964) and **260**, 3327 (1965).
50. H. G. Dehmelt, *Phys. Rev.* **105**, 1924 (1957); W. E. Bell and A. L. Bloom, *ibid.* **107**, 1559 (1957).
51. C. Cohen-Tannoudji, thesis, *Ann. Phys.* **7**, 423 469 (1962).
52. J. P. Barrat and C. Cohen-Tannoudji, *Compt. Rend.* **252**, 93 (1961); *J. Phys.* **22**, 329 (1961).
53. See (*51*) and A. Kastler, *J. Opt. Soc. Amer.* **53**, 902 (1963).
54. E. B. Alexandrov, A. M. Bonch-Bruevich, N. N. Konstin, V. A. Khodovoi, *JETP Lett.* **3**, 53 (1966).
55. N. Polonsky and C. Cohen-Tannoudji, *J. Phys.* **26**, 409 (1965); ———, *Compt. Rend.* **260**, 5231 (1965) and **261**, 369 (1965); C. Cohen-Tannoudji and S. Haroche, *ibid.* **261**, 5400 (1965).
56. C. Cohen-Tannoudji and S. Haroche, *Compt. Rend.* **262**, 268 (1966).
57. ———, *ibid.*, p. 37.
58. J. Margerie, thesis, *Publications Scientifiques du Ministère de l'Air* (1966), N. T. 155; J. Brossel and J. Margerie, in *Paramagnetic Resonance*, W. Low, Ed. (Academic Press, New York, 1963), vol. 2, p. 535; N. V. Karlov, J. Margerie, Merle d'Aubigné, *J. Phys.* **24**, 717 (1963); see also A. Kastler, in *Lasers and Applications*, W. S. C. Chang, Ed. (Ohio State Univ. Press, Columbus, 1963).

Bibliography

H. Kopfermann, "Kernmomente," *Akad Verlagsgesellschaft* **2**, Auflage 1956, § 24: "Die Doppelresonanz methode."
A. Kastler, *J. Opt. Soc. Amer.* **47**, 460 (1957); *Physikertagung* (Physik Verlag Mosbach, Wiesbaden, 1960), p. 62; *Proceedings of the Ampère Colloquium, Eindhoven* (North-Holland, Amsterdam, 1962); *J. Opt. Soc. Amer.* **53**, 902 (1963).
G. W. Series, *Rep. Progr. Phys.* **22**, 280 (1959).
G. zu Putlitz, *Ergeb. Exakt. Naturewiss.* **37**, 105 (1965).
J. Brossel, *Yearbook Phys. Soc. London* (1960), p. 1.
J. Brossel, in *Quantum Electronics I* (Columbia Univ. Press, New York, 1960), p. 81; in *Quantum Electronics II* (Columbia Univ. Press, New York, 1961), p. 95; *Proceedings of the Les Houches Conference on Optics and Quantum Electronics* (Gordon and Breach, New York, 1964), p. 187.
G. V. Skrotsky and I. G. Izioumova, *Soviet Phys. Usp.* **4**, 177 (1961).
R. A. Bernheim, *Optical Pumping; An Introduction* (Benjamin, New York, 1965).
A. Kastler, in *Proceedings of the Zeeman Centennial Conference* (Netherlands Physical Society, Amsterdam, 1965), p. 73.
C. Cohen-Tannoudji and A. Kastler, in *Progress in Optics* (North-Holland, Amsterdam, 1966), vol. 5, p. 1.
A. Kastler, in *Proceedings of the Ampère Colloquium, Ljubljana, 1966* (North-Holland, Amsterdam, in press).
A. L. Bloom, *Sci. Amer.* **203**, 72 (1960).
R. de Zafra, *Amer. J. Phys.* **28**, 646 (1960).
T. R. Carver, *Science* **141**, 599 (1963).
R. Benumof, *Amer. J. Phys.* **33**, 151 (1965).

Food Proteins: New Sources from Seeds

Fortified and processed seed proteins have a role in satisfying human protein needs.

Aaron M. Altschul

The problem of protein malnutrition is well recognized and appreciated. The effects of such deprivation on young children influence their resistance to disease and hence their mortality, and, perhaps more importantly, affect their mental development. When there is not enough food to sustain life, quality of food is of little significance. But when even the minimal supply of food is available, then the protein quality of the food is critical. Hence the protein malnutrition problem is second only to the total food-supply problem.

About 50 percent of the children in the world do not receive adequate protein nutrition. If we take the FAO (Food and Agricultural Organization of the United Nations) short-term goals of 69 grams of total protein and about 15 grams of animal protein (good protein) per day per person for the countries where the food supply is marginal (*1*), the protein deficiency expected in 1970 is estimated to be 10 million tons, of which 5.5 million tons is animal protein. The total protein deficit expected is 12 percent of the present supply; the deficit of good protein is 22 percent of that available now. Another estimate is provided in the World Food Budget (*2*). Aside from the protein supplied by grains, 6.5 million tons of nonfat dry milk or 3 million tons of fish protein concentrate will be needed by 1970 to fill the animal protein deficit, and 3.2 million tons of soybean protein concentrate to fill the pulse and other protein deficit (*1–5*).

Let us assume that the problem we are trying to solve is to increase pro-

The author was formerly Chief Research Chemist, Seed Protein Pioneering Research Laboratory, U.S. Department of Agriculture, New Orleans, Louisiana. He is now Special Assistant for International Nutrition Improvement, International Agricultural Development Service, U.S. Department of Agriculture, Washington, D.C. 20250. This is the text of an address delivered 26 December 1966 at the Washington meeting of the AAAS.

tein supply without requiring added agricultural production. This does not minimize that which can be added through additional agricultural production; we assume that as much of this as can be done is being done. The issue is whether there now exists a technology for improving current production of protein or rendering it more suitable for humans.

We recognize a relation between protein quality and quantity. The quantity of available protein in a diet can be increased if the total food intake is increased. If this requires the mixing of several types of protein, there is a good chance that the quality is improved as well. Moreover, even if the amount of protein in the diet is not increased, its quality may be improved if the "amino acid profile" is adjusted so that the protein is better suited for human nutrition. This improvement, in effect, increases the quantity because it reduces the amount of protein required to satisfy the individual's protein requirements. Smaller quantities of high-quality protein will do as well as greater amounts of protein of lesser quality. Abbott (*3*, p. 11) points out, for example, that average protein requirements for the United States are 40 grams per day per person compared to 52 grams for Yugoslavia. This difference is a reflection principally of the biological quality of the protein in the two national diets; it means that there is waste when lower quality protein is used.

Table 1. Lysine supplementation of cereal grains (*17*).

Cereal	Nutritive value*		Lysine added† (%)	Estimated cost‡ (cents)
	Original	After supplementation		
Whole wheat	1.3	1.7	0.1	28
Wheat flour	0.7	1.6	0.25	70
Rice	1.5	1.8–2.2	0.05	14
Corn	1.5	1.9–2.2	0.1	28
Millet	0.7	2.1	0.3	84
Sorghum	0.7	2.2	0.3	84
Casein		2.5		

* In terms of protein efficiency ratio (PER) determined on rats. † Added as L-lysine HCl. ‡ Cost of supplementing cereal per child per year based on an assumed cost of $1.00 per pound.

Increasing Protein Supply without Additional Acreage

With this concept in mind, we can increase the supply of protein without requiring additional acreage in three ways: (i) by increasing the efficiency of photosynthesis; (ii) by fortifying plant proteins without introducing new food habits; and (iii) by feeding directly to humans those proteins which are not now primarily eaten in human food.

Breeding improved quality. An example of the first instance is the improvement in protein concentration or quality of cereal grains through manipulation of the germ plasm. The genetic manipulation of corn which yields a variety with a higher lysine and tryptophan content could revolutionize the role of corn in human foods (*6*). Comparable research to increase the protein content of wheat and rice or to improve their protein quality could materially increase their nutritional value in the human diet. The overriding consideration, however, is yield; any improvement in nutritional quality at the expense of yield will be difficult to justify either to the farmer or to a government faced with a shortage of calories.

Fortification of cereals. The major contributor of protein to human foods is grain which, as cereal, contributes 40 million tons of protein annually to the human diet; this figure should be compared to 25 million tons from animals and 12 million tons from legumes. Hence, any improvement in the protein quality or quantity in the cereal grains has the best chance of serving the widest population. This is particularly true in countries where cereal grains are a major source of calories, as, for example, the rice- and wheat-eating populations of Asia and North Africa and the corn-eating populations of Central and South America. Cereals can be fortified by the addition of amino acids (*7*), protein concentrates, or a combination of the two.

Suitable quantities of the first limiting amino acid, which for all of the major cereals is lysine, may be added. The protein nutrition value of these grains is improved by addition of small quantities of this first limiting amino acid; the degree of improvement varies with the varieties of grains. An idea of what may be accomplished by addition of lysine alone is shown in Table 1. If the second amino acid in which grain is deficient could be added as well (tryptophan for corn, or threonine for rice and wheat), then the protein quality would be greatly improved; cereal so enhanced would be considered good, safe protein. Lysine and methionine are available commercially at prices ranging from $1 to $1.50 a pound; DL-tryptophan and DL-threonine are available at prices ranging from $4.50 to $7.50 per pound. The improvement of wheat with L-lysine (0.10 percent of the grain) is now practical and cheap; so also is the complete improvement of corn with lysine (0.2 to 0.3 percent) and DL-tryptophan (0.05 to .07 percent). The complete improvement of wheat or rice which requires L-threonine (0.15 for wheat grain and 0.1 percent for rice) in addition to the L-lysine (0.3 percent for wheat and 0.2 percent for rice) will become practical as the price of L-threonine is lowered below about $2 a pound ($4.40 per kilogram). We should stress the significant variability of the cereal grains; some varieties show more improvement by fortification with lysine alone than others do. Hence, any formula of single or multiple fortification must be adjusted for the particular variety of plant product being treated.

Whereas supplementation of animal rations with amino acids is now widespread and automatic, amino acids are still not often used to improve protein diets for humans. However, some recent developments should stimulate further experimentation and lead to reevaluation of the entire situation. In reply to a letter from Secretary of Agriculture Freeman, F. Seitz, president of the National Academy of Sciences, was of the opinion that lysine could be used to fortify wheat, and that it would be desirable to work out the logistics of supplementation on a large scale, under actual living conditions (*8*). Similar views were expressed by the Protein Advisory Group of the United Nations, the *ad hoc* panel on protein of the UN, and the President's Science Advisory Committee in the report, *The World Food Problem.* Accordingly, such demonstrations are being arranged for the fortification of wheat and corn in several countries where these cereals are the major components of the diet and where protein-calorie malnutrition exists among children. Even fortification of rice is being considered despite the high cost of threonine, on the presumption that this price can be lowered in large-scale production.

The proposed demonstrations would determine whether it is possible to develop proper logistics and whether the fortification with amino acids actually reaches the plate of the consumer. While there is general agreement that there is no toxicity to proper fortification with amino acids and that the protein quality in the cereals is improved thereby, there is no information on what one might expect to happen under the real-life conditions in any community where fortification would be practiced. Such real-life conditions might include less than optimum caloric intake and frequent inclusion of protein-rich foods such as legumes. This information is not considered necessary in order to go ahead with a fortification program, particularly in emergency feeding programs; yet it is generally considered essential for evaluation of the benefits of such a program as related to cost and for long-time acceptance of this view. This is not a problem confined to fortification of cereals with amino acids: this is a problem wherever any kind of fortification is practiced or, for that matter, when any kind of a public health improvement is fostered.

Small quantities of protein concentrate such as concentrates from soy, cottonseed, or peanut, or from fish might be added to cereal flours as an alternative. Such programs have the advantage that not only is the quality improved, but the percentage of protein consumed is also increased. Where the mixture now is deficient in either lysine or methionine, this deficiency can be remedied by further addition of these amino acids. Hence we are considering a three-element situation consisting of cereal grain, amino acids, and protein concentrates. In every instance there ought to be, on the basis of availability and local customs, a mixture of the three that would be optimum for fortifying the grain without alteration of traditional food habits.

The major notion is that eventually all cereal grains should provide the greatest protein possible: first by being bred to provide the greatest protein impact genetically possible, and second by being fortified with amino acids and protein concentrates to maximize the protein value without changing the food use.

New protein foods. Low-cost protein foods could be developed by utilization of protein supplies that hitherto have not been fed to humans. Let us consider first the instances of foods based on cereals to which oilseed protein concentrates are added. In this category we have emergency weaning foods and new protein foods having a wide variety of properties.

As a result of its emergency milk programs the United Nations International Children's Emergency Fund (UNICEF) showed that one can reduce and control protein malnutrition among children and mothers by supplementing their diets with dry milk solids. This was a wonderful program as long as surplus milk solids were available for distribution in large quantities. But this era has ended. Now the need is greater, and the amount of milk solids available is drastically reduced. Hence there is a need for mixtures of good protein quality, preferably from indigenous sources, which can provide the same impact as milk solids.

It is now quite clear from demonstrations made particularly by INCAP (Institute of Nutrition for Central America and Panama) that all-vegetable protein mixtures can be suitable for children (*9*). These mixtures can cure kwashiorkor and, of course, can prevent it. It is, therefore, now possible to conceive of weaning foods that would be available and could be fed in child-feeding programs. One such mixture of a weaning food which still contains milk, but in small quantities, and which is a prototype of other mixtures is the so-called CSM formula (corn, soya, milk) which is now being tested extensively in child-feeding programs. Seventy percent of this mixture is processed corn, 25 percent is soy protein concentrate, and 5 percent is milk solids. Other nutrients, such as vitamins and trace metals, are added as supplements when necessary.

It is now conceivable that low-cost weaning foods can be made available in areas where there is a shortage of such high-protein materials of adequate quality. If the protein quality of the weaning food is not adequate, one can improve it by adding amino acids. For example, the protein quality of "Incaparina," which already is adequate to cure kwashiorkor can be greatly improved by the addition of lysine, and this has now been recommended by INCAP.

Ultimately there is need for a general class of new foods based on low-cost protein concentrates, and these must be adequate nutritionally and satisfactory esthetically. An enormous effort is now underway to make such foods available in the marketplace. The food industry is being encouraged to engage in such developments. Where protein malnutrition exists, governments are being encouraged to aid in these efforts.

A wide variety of food products is now being studied, and in some instances these products are already being marketed (*10*). Some now offered as commercial products would include "Pro-Nutro," in South Africa; Incaparina, in Colombia and Guatemala; and "Vita-Soy" in Hong Kong. The new types of foods range in sophistication from mixtures of cereal and protein concentrates that are not different in principle or in properties from the child-weaning foods mentioned above to the most sophisticated offerings such as spun-fiber textured protein products made from isolated protein. Others include, in addition, flaked or extruded cereal protein-concentrate mixtures, protein beverages (such as Vita-Soy), high-protein baked goods, protein spreads, protein desserts, and textured products. The textured foods thus far have been made with soy protein, but the same types of products could be made from other protein concentrates such as peanut and cottonseed.

Economics of New Foods

The economic considerations of new foods are simple. Processing costs, such as costs of improving the quality and enriching taste and acceptability, are balanced against the cost of inserting an animal as an intermediate. On the basis of current experience, the job can be done in the factory and with greater versatility at costs ranging from one-half to one-fifth the cost of producing animal protein (*3*, p. 14).

In practice, fortification programs would initially be supported by governments, and perhaps this support would continue for a long period until the cost can be borne by the consumer. Likewise, supplies of weaning foods will have to be furnished as part of relief programs to take care of the sensitive portions of the population. At first, the new protein foods will probably be bought by consumers who will benefit by the lowered cost of their protein but whose protein diets will not be as deficient as those of the very low income groups. In the process of improving the economic situation and the food supply, one could envisage the commercial new protein foods becoming available to increasingly lower economic strata, as the cost of production decreases.

As a matter of history, the need for more and better foods as income rises was solved by increasing the animal population; this will continue wherever possible (Table 2). But obviously this demand for more animal foods cannot be met fully or even in small measure in many parts of the world. However, the new low-cost protein foods provide an alternative for people who will be wanting better food. Particularly the beverages and textured foods (*11*) show promise of being attractive as well as nutritious. The first textured foods are not too far removed in appearance and flavor from animal protein products. But there is no reason to believe that this is the limit of capability. Nor, as in the development of any new art form, can one predict the boundaries of imagination. This new development of texture in processed protein foods could even be as far-reaching in its effect on human society as the discovery of bread so many thousands of years ago.

Oilseeds as Human Foods

A major low-cost source of protein is the oilseeds, particularly soybeans, cottonseed, and peanuts (*4*, p. 278; *12*). The production of these in 1965–66 throughout the world was the equivalent of 13.7, 4.4, and 3.2 million tons of protein, respectively. Together, oilseeds have the potential of furnishing almost as much protein annually for man as that available from animal sources of protein. They are now a major source of protein in animal feeds; and if oilseeds were transformed into human foods, other protein sources, perhaps not satisfactory for humans, would be needed for animals.

Soybeans. Soybeans have been a source of protein for humans for thousands of years. In many parts of the world, it is indeed still the practice to depend heavily on this seed (*13*). The ancient peoples extracted or fermented the soybean to destroy or remove deleterious factors; modern technology has provided additional procedures. Four types of modern soy products are available. In order of increasing costs, they are soy protein concentrate for human use (50 percent protein), full-fat soy flour (40 percent protein), soy protein concentrate (70 percent protein), and soy protein isolate (more than 95 percent protein). They range in price from 14 to 40 cents per pound of protein. The full-fat product as well as the 50 percent product can be used in cereal-protein mixtures, in beverages, in baked products, and, in some instances, in textured products. They have the advantage of low cost; they have the disadvantage that they still retain some factors which interefere with their use as human food. For example, such soybean products may cause flatulence, and their flavor is not always attractive.

The 70 percent protein concentrate has maximum nutritive value; it is palatable and free of deleterious products. It should have broad general application and can be incorporated into textured products more easily.

A major virtue of the protein isolate (95 percent) is that it can be spun into fiber and therefore be incorporated into sophisticated textured products.

However, in the process of isolation there is selective concentration of protein, with the result that the proteins of the isolate have a lower nutritive value than the total proteins of the original soybean. This difficulty can be remedied by blending the soy protein with other products in the course of the spinning and texturizing operation. Products which simulate meat, fish, and poultry have been made from such material.

Whereas soybeans grow well in temperate climates, they have not yet been grown economically in tropical climates; hence, they are not a major crop in Central America, most of South America, Africa, India, and Pakistan. Attempts are being made now to determine to what extent soybeans can be grown in countries such as India. If they could be made an indigenous crop, this would be a great new source of protein for India, and perhaps they could be cultivated on land used for nonfood products. Or, it may turn out that it is cheaper to grow soybeans in temperate climates. With the efficiency of North American production, it may be more economical to produce this commodity in the United States.

It certainly would be worth while to use soy products wherever possible in new formulations, either for fortification of cereals, in children's foods, or in new foods. Even in areas where soy products are not now available, it would be practical to start, at least, to develop these new approaches with soy products obtained elsewhere; in the meantime, efforts should be made to determine how far and to what extent soybeans can be extended to areas where they do not now grow. At the same time we should accelerate research to remove physiological and flavor factors which are now in soybean products and which may interfere with their fullest utilization in human foods.

Cottonseed. Upon removal of oil and seed coat from cottonseed, a concentrate with 50 to 55 percent protein may be obtained. This can be concentrated to 70 percent by extraction of carbohydrates. The 50 percent concentrate, prepared by screw-pressing or by prepressing and subsequent solvent extraction, has been fed successfully to humans and is included up to 38 percent in Incaparina, the cottonseed protein-corn product marketed in Latin America (*14*). Its nutritive value can be improved by addition of small amounts of lysine. The types of food into which cottonseed protein concentrate may be added are limited by its brown color.

Glandless varieties of cottonseed (that is, those free of gossypol, a colored toxic phenolic component) were discovered over 10 years ago. Protein concentrate from glandless cottonseed has superior nutritive value over the protein concentrate from ordinary cottonseed, and its color is excellent. Further development of the glandless variety of cotton should be encouraged. Since the major economic component of cotton is the lint, the yield of this product will determine the extent of interest and the rate of development of the new variety. Concomitantly, therefore, research should be intensified on more sophisticated methods of processing to eliminate gossypol and color in the products from normal seeds.

Cottonseed protein concentrate has been demonstrated to be suitable for human consumption. Its use in formulations like Incaparina should be extended to other weaning mixtures where it can replace milk solids and some of the soybean protein. Cottonseed protein has the great virtue in that it comes from a plant that is indigenous to protein-poor tropical areas of Asia, Africa, and Latin America.

The cost of the present products which contain 50 to 55 percent protein could be expected to range from 12 to 18 cents per pound of protein.

Peanuts (*groundnuts*). Peanuts are another major oilseed crop. That part of the peanut crop consumed by humans is eaten as whole kernels. The United States is almost unique in its consumption of peanut butter; on the average, more than 1 gram of protein per person per day comes from this source. When the peanut is processed to remove the oil, there results a protein concentrate (50 percent) which certainly ought to be considered for human foods. It is also possible to produce a protein isolate and a protein-oil product (70 percent protein, 30 percent lipid). The latter product might have particular usefulness in beverages.

Peanut protein is deficient in three amino acids—lysine, methionine, and threonine—as compared to soybean protein which is deficient principally in methionine and is a good source of lysine. Hence peanut products would probably not be recommended as a component of all vegetable products unless they are supplemented with amino acids or with other sources of good protein to make up for this deficiency. Nevertheless, there is a place for peanut protein products, and their use should be encouraged wherever possible. Peanuts are indigenous to the Caribbean Islands, to South America, and to Africa; and a large amount of peanuts is grown in India. The addition of this source to the world protein supply could measurably reduce protein malnutrition.

One of the disadvantages of peanuts is the possible presence of aflatoxin, a mold metabolite contaminating many kinds of seeds, and first discovered in peanut meal. Considerable research is now under way, and this should be accelerated, on ways and means of removing the contaminating aflatoxin of the peanut. However, aflatoxin should not in any way interfere with the present development of peanut products, since careful handling and picking can reduce the aflatoxin content to manageable proportions. Therefore, we should now make every effort to introduce peanuts into dietaries and use careful means of selection to assure freedom from aflatoxin; at the same time, we must continue research to eliminate the aflatoxin problem.

Processed seed proteins. In order to focus attention on opportunities for immediate improvement in protein supply for large populations, I have deliberately confined this discussion to proteins from seeds that are processed in some manner before human consumption. Seeds are by no means the only sources of low-cost protein; vast quantities of legumes are used in every culture, and other sources are fish protein concentrate, leaf protein, and the protein from microorganisms grown on carbohydrates or on hydrocarbons.

In all instances, the use of protein concentrates for human consumption involves an essential processing step. If the processing is not done correctly, the product may not be completely satisfactory, and the protein value may indeed be damaged. Therefore, it is not sufficient to talk about processed products from soy, cottonseed, peanuts, fish, or the like. It is necessary to talk about particular products meeting well-defined specificiations. Such specifications have been prepared by UNICEF for cottonseed, peanut, and soy products; and they, no doubt, will be refined as more information is available (*10*).

Table 2. Relation of animal protein consumption to affluence. Comparison of various countries based on national product per capita (*4*, p. 183; *18*).

Group	National product 1950–59 (per capita U.S. dollars)	Consumption 1954–57 (per capita per day)	
		Calories	Animal protein (g)
I	1000–1870	3120–3390	52–71
II	750– 950	2980–3340	43–56
III	500– 740	2980–3230	43–58
IV	250– 460	2560–2900	24–56
V	60– 230	1880–2660	6–23

The Question of Energy

The proposal for new food products, indeed all the proposals discussed here, introduces food processing as an essential component of the food chain. This requires energy—energy additional to the solar energy of photosynthesis involved in the production of the raw plant products. It would be worth while to consider the energy aspects of the matters we have been discussing.

Actually, in terms of renewable energy, an economy based on animals as an important component is efficient. The animal can survive on products of photosynthesis and provides good protein, power, and materials for clothing, fertilizer, and fuel. At low population densities, animal production is a workable solution to the problem of acquiring enough food.

But with the present increasing world population, those societies which still depend primarily on renewable energy cannot afford a substantial portion of animal food. In that part of the world which is protein poor and which does not use much fossil fuel —either because it is unavailable or because of lack of technology—the animal-protein consumption is 9 grams per capita per day as against that in the rest of the world, where the consumption is 44 grams.

Even though man's additional input to the world's energy pool is small compared to that of the solar energy, it is significant and has made all the difference in our way of living. In 1947, for example, the annual output of energy per capita in the United States was equivalent to 2.6 tons of coal or to 10 horsepower per capita. These values have risen to 10 tons of coal equivalent or to 75 horsepower (*15*).

This additional energy has sustained our way of life. It has contributed to the abundance of our food supply. I would not pretend to estimate the percentage of nonreplaceable energy devoted to food procurement. One might get some idea of its magnitude from the fact that at present an estimated 33 percent of the labor force in the United States is considered part of the "agri-business" complex.

It would seem that with the present world population, additional nonreplaceable energy is required to satisfy the need for food. In a situation where only 150 kilowatt-hours per capita per year of electric power are available in less-developed countries as compared to 3740 kilowatt-hours in the developed areas (*16*), additional energy will be required for increased and improved procurement of food. The problem facing the underdeveloped individual countries and that part of the world which assumes responsibility for helping them is to find this additional energy and technology and to use them at the lowest possible cost. At the moment, the only valid considerations are those which require withdrawing from our capital energy resources; we are cognizant of the general problem of the future of energy supplies.

Relation to Population Growth

Under no circumstances should we consider that we have infinite capacity to increase either our total food or our protein supplies. All this makes sense only in view of concomitant strenuous efforts to control population growth so that eventually we may conceive of bringing food and population in balance.

Summary

Adequate protein nutrition is possible at lower cost without the undermining of man's satisfaction with his food. This potential requires the upgrading of the proteins of cereals by supplementation with amino acids and the development of new protein foods from low-cost sources such as the oilseeds; infant malnutrition can be eliminated by such means. The more sophisticated new foods such as protein beverages and textured products are proving acceptable to man and will supplement meager supplies of animal protein.

References and Notes

1. "State of food and agriculture," *Food and Agriculture Organization of the United Nations* (Rome, Italy, 1964), chap. 3.
2. "The world food budget, 1970," *Foreign Agriculture Economic Rept. 19* (U.S. Dept. of Agriculture, Washington, D.C., 1964).
3. J. C. Abbott, *Advances Chem.* **57**, 1, (1966).
4. A. M. Altschul, *Proteins, Their Chemistry and Politics* (Basic Books, New York, 1965), p. 228.
5. P. V. Sukhatme, *J. Roy. Statist. Soc.* **124** part 4, 463 (1961).
6. *Proceedings High-Lysine Corn Conference Purdue University 1966* (Corn Refiners Association, Washington, D.C.); N. E. Borlaug, *Phytopathology* **55**, 1088 (1965).
7. E. E. Howe, G. R. Jansen, E. W. Gilfillan, *Amer. J. Clin. Nutr.* **16**, 315 (1965); R. Bressani, D. L. Wilson, M. Behar, N. S. Scrimshaw, *J. Nutr.* **70**, 176 (1960).
8. *Proceedings of the Food and Nutrition Board* (Natl. Research Council, 1966), vol. 26, p. 4.
9. R. Bressani, A. Aguirre, L. G. Elias, R. Anoyave, R. Jarquin, N. S. Scrimshaw, *J. Nutr.* **74**, 209 (1961).
10. E. Orr and D. Adair, *The Production of Protein Foods and Concentrates from Oilseeds* (Tropical Products Institute, London, England, June 1967).
11. W. W. Thulin and S. Kuramoto, *Food Technol.* **21**, 168 (1967).
12. A. M. Altschul, Ed., *Processed Plant Protein Foodstuffs* (Academic Press, New York, 1958).
13. *Soybean Protein Foods,* Proceedings of an International Conference, Peoria, Ill., 17–19 Oct. 1966 (Agricultural Research Service, U.S. Dept. of Agriculture, ARS-71-35, 1967).
14. R. Bressani, L. G. Elias, E. Braham, *Advances Chem.* **57**, 75 (1966).
15. P. C. Putman, *Energy in the Future* (Van Nostrand, New York, 1953), p. 93; H. Nichol, *J. Roy, Inst. Chem.* **88**, 423 (1964).
16. *Statistical Yearbook, 1965* (United Nations, New York), p. 348; *Selected Economic Data for the Less Developed Countries* (Agency for International Development, Washington, D.C., June 1967).
17. E. E. Howe in *Proc. Conf. Technol. Food Supply, 25 Oct. 1966* (Dairy and Food Industries Supply Association, Washington, D.C., 1967), p. 60.
18. L. R. Brown, "The world food/population problem: An overview", in *Conference on Alternatives for Balancing Future World Production and Needs* (Ames, Iowa, 8 Nov. 1966).

The Promise of the International Atomic Energy Agency

Glenn T. Seaborg

Earlier than most men, scientists recognized that the successful occupancy of this tiny planet by man could best—or perhaps only—be accomplished through international cooperation. Indeed, I suspect that many scientists are inclined to believe that the very existence of the term "international cooperation" implies an artificial and unfortunate separation into arbitrary components of what is obviously a single, interdependent physical and biological system. Yet that separation exists, and it is to the credit of science and scientists that they have found ways to minimize its impact in their own affairs. Important as international scientific cooperation is in its own right, perhaps its most profound current significance is that it is showing the way increasingly to cooperation between nations in matters which can affect the well-being and even the life and death of millions of human beings. By the example of institutions such as the International Theoretical Physics Conference, by the active participation of scientists in the affairs of government, and in many other ways, scientific internationalism is transforming relationships between countries. It is doing this far more quickly and more profoundly than most of us, even those close to the scene, realize. We can only hope that it is working this transformation quickly enough.

The author is chairman of the U. S. Atomic Energy Commission, Washington, D.C. 20545. This article is adapted from an address delivered before the International Theoretical Physics Conference on Particles and Fields at the University of Rochester on 31 August 1967.

Formation of IAEA

What I have in mind is perhaps nowhere better illustrated than by the International Atomic Energy Agency. I believe its accomplishments and its prospects for the future hold deep significance for progress in international institutions, both scientific and otherwise. The IAEA was born out of a realization that the promise and the problems of the peaceful uses of nuclear energy recognize no national boundaries. The United States' proposal to create this agency in 1953 marked the turning point in the postwar evolution of nuclear energy from its preoccupation with military uses to an emphasis on peaceful uses open to all. In little more than 3 years, not an extended time for the formation of an international organization, the agency was established. It was established at a time when achieving international agreement in even the most minor matters was far more difficult than it is today. I believe it is possible to say that the creation of the agency was one of the early and significant demonstrations that a widely favored international objective can be achieved even in a climate of controversy between the major powers.

Today, the IAEA has achieved the status of a healthy youngster in the family of international organizations. It is 10 years old, with 97 members, and