There is a complex relationship between the agricultural and chemical industries. The chemical companies sell many products to the farmer, and the chemical companies buy many products from the farmer. Frequently the chemical industries improve the properties of agricultural products before using them or reselling them. In a number of cases, the chemical industry and the agricultural industry are in direct competition. This paper discusses each of these facets of the relationship and attempts to predict the future relationship between these two important segments of our society.

**A Consumer of Chemicals:** The availability of chemical fertilizers, feed supplements, herbicides, insecticides, fungicides, rodenticides, etc. makes it possible to farm more efficiently and produce farm products at a lower cost. In most cases, these improvements have been joint efforts between agricultural scientists and representatives from the chemical industry. For reasons best known to you, farm efficiency does not seem to be as important as it once did. Some economists have suggested that a tax be levied on chemical fertilizers to discourage their use. Although this might be effective in reducing production, there must be more direct methods of making agriculture less efficient and adding to production costs.

The phosphate fertilizer manufacturers provide more than 10,000,000 tons of product annually, and this is now the fastest growing branch of the inorganic chemical industry. Present trends indicate that this growth rate will continue for quite some time.

Because the annual loss by agricultural pests is about $10,000,000,000 and the amount spent for pesticides is only a small fraction of that, one can expect a continued growth of chemical pesticides.

**Raw Materials for the Chemical Industry:** The chemical industry has used various agricultural products as raw materials for many years. About 2,000,000,000 pounds of starch are produced from cereal products each year. Almost 70 percent is used in the various chemical industries.

Morton Smutz is Head, Chemical Engineering Department, Iowa State College.
Large quantities of cellulose are obtained from cotton and wood. Over 100,000 tons of cotton linters are processed annually to produce the cellulose needed to make rayon, cellulose acetate (60,000,000 lbs. per year for cigarette filters), plastics, etc.

Large quantities of grains are used in the production of various alcoholic beverages such as beer and whiskey. Large quantities of vegetable and animal oils are used in the soap and paint industries.

Improvement of Agricultural Products: Many examples could be cited showing how the chemical industry improves the quality of agricultural products. The hydrogenation of fats and oils has had a big impact on the industry. Over 3,000,000,000 pounds of hydrogenated oils are produced in the United States each year.

The application of solvent extraction as a processing technique has resulted in more and better soybean oil at a lower price. The Solexol process is used to split soybean oil into two fractions. One fraction is a better drying oil and the other is a better edible oil. Various "fat splitting" techniques have made fatty acids available. The Emersol process makes it possible to separate the fatty acids on the basis of saturation. Vacuum distillation techniques separate fatty acids according to molecular weight.

Competitors: Many examples can be cited showing how the chemical industry has reduced the demand for agricultural products by providing a better product or a more economical product for the consumer. One example is that of industrial alcohol manufacture. For many centuries, ethyl alcohol has been made by the fermentation of starch or sugar. Until recently, very large quantities of corn and sugar were used to produce our alcohol requirements. During the past few years, almost all of the non-beverage alcohol has been made by the chemical industry using ethylene from natural gas as the starting material. In this process, ethylene is reacted with water to produce low cost high purity alcohol. Although estimates vary, corn would have to cost less than 50 cents per bushel to be seriously considered as a raw material for non-beverage industrial alcohol manufacture.

During World War I, one of the remarkable contributions of the chemical industry was the manufacture of acetone and butyl alcohol by the fermentation of starch containing grains. The petrochemical industry now produces almost all of the acetone required.

We are all familiar with the popularity of the synthetic fibers such as nylon, orlon, dacron, dynel, etc. Although cotton still reigns supreme, the growth of the synthetic fibers has been spectacular. Recent predictions (March 30, 1959 Chemical and Engineering News) indicate that the sale of noncellulosic
synthetic fibers will increase by 145 percent between now and 1965.

Latex based paints were introduced commercially in 1948 and grew very rapidly. In 1953 latex paint sales amounted to over 40,000,000 gallons. You and I enjoy using this type of paint because it is almost "streak proof", dries quickly, has low odor and is durable. This type of paint has increased the demand for butadienestyrene copolymer and reduced the demand for vegetable, animal and fish oils.

Chemurgy Research: Many capable scientists and engineers have devoted their lives to research hoping to find more industrial uses for agricultural products and byproducts. The research work by industry, the four Regional Laboratories, and by universities have developed some successful processes. In recent years, however, developments in the chemical industry have reduced the demand for agricultural products rather than stimulated new uses.

It is possible to make hundreds of chemical substances from agricultural products and byproducts. In most cases it is possible to make the same products more economically by simpler direct chemical reactions using products from natural gas or crude oil as starting materials.

The greatest potential in finding new industrial uses for agricultural products would seem to be to find the most economical way to isolate the most complex chemicals present and to seek new uses for them. The chemical industry would develop alternate ways of producing some of these compounds, but some would survive the competition. Too little research of this kind is now being done.

The Future: 1. The farmer will continue to buy chemical fertilizers, pesticides and feed supplements in ever increasing quantities.

2. Over a period of years we will gradually exhaust our non-renewable sources of organic chemicals; natural gas, crude oil and coal. We will gradually become more dependent on renewable sources.

3. The amount of agricultural products used for industrial purposes will depend upon the cost of these products to the chemical industry, the amount of research done to develop new uses, and unpredictable new technical developments.

4. As advances are made in fundamental chemistry and chemical engineering science, the chemical industry will be able to produce more complex chemicals economically on a large scale. It is possible to foresee the possibility of direct competition between the chemical industry and the agricultural industry in the food market.
5. The same vertical integration developments taking place in poultry and meat processing will take place in supplying raw materials to the chemical industry. The possibility of more stable prices would encourage the use of agricultural products as raw materials.