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ABSTRACT

Comparisons of average food prices and hourly wages based on 40-hours work week in various capital cities of the world are presented. Such factors as mechanization, chemicals, and improved genetics have resulted in greater productivity, fewer but larger farms, and hardier plants and animals. The economic effects are discussed as they are felt by both the producers and consumers. The booklet concludes with two student projects and a quiz. (EH)

ECONOMIC ISSUES

for Food, Agriculture & Natural Resources

Purdue University School of Agriculture Fall 1990 No. 4

:: *Economic Effects of Technological Advances in Agriculture*

INTRODUCTION

CHEAP FOOD SUPPLY — As Americans, we have a cheap food supply compared to consumers in other countries. On average, American consumers spend only 14% of their disposable income (money left after taxes) on food. Food costs vary greatly around the world (Table 1). However, simply comparing food prices can be misleading. It is more appropriate to compare the time an average worker must work to pay for an item. For example, a kilogram of steak (2.2 lb.) costs $33.54 in Bern but only $4.78 in Mexico City. However, an average Swiss worker needs to work only two hours and 39 minutes to pay for that kilogram of steak, whereas the average Mexican must work more than four hours. In Washington, D.C., an average worker only needs to work 58 minutes to purchase a steak that costs $9.74 per kilogram.

Neighborhood restaurant near Kuala Lumpur, Malaysia

ABOUT THE COVER: Picture represents new discoveries in the application of biotechnology to agriculture.

Economic Issues...is published by the Office of Academic Programs, ... A. Welch, Editor.

Comparison of average food prices and hourly wages based on 40-hour work week in various capital cities.

TABLE 1

AVERAGE HOURLY WAGE		SIRLOIN STEAK- 1 KG.		RICE- 1 KG.		ORANGES- 1 KG.	
City	$ U.S.	$ U.S.	Time	$ U.S.	Time	$ U.S.	Time
Bern	12.63	33.54	2:39	2.18	0:10	1.49	0:07
Brasilia	1.18	3.65	3:06	.71	0:36	.77	0:39
Buenos Aires	0.88	2.35	2:40	1.47	1:40	.67	0:46
Canberra	7.98	7.87	0:59	.94	0:07	1.52	0:11
London	7.03	14.25	2:02	1.73	0:15	3.02	0:26
Madrid	4.60	13.68	2:58	1.97	0:26	1.44	0:19
Mexico City	1.10	4.78	4:21	.56	0:31	.64	0:35
Ottawa	10.00	9.35	0:56	2.02	0:12	1.85	0:11
Pretoria	1.23	5.22	4:15	.95	0:46	.58	0:28
Seoul	2.38	17.25	7:15	1.85	0:47	12.15	5:06
Tokyo	11.15	45.68	4:06	2.27	0:12	3.57	0:19
Wash., D.C.	10.10	9.74	0:58	1.85	0:11	1.79	0:11
Your Wage/Store	_____	_____	_____	_____	_____	_____	_____

	WHOLE MILK- 1 liter		POTATOES- 1 KG.		PORK ROAST- 1 KG.	
City	$ U.S.	Time	$ U.S.	Time	$ U.S.	Time
Bern	1.22	0:06	.89	0:04	12.11	0:58
Brasilia	1.06	0:54	.54	0:27	5.41	4:35
Buenos Aires	.64	0:44	.33	0:23	5.09	5:47
Canberra	.67	0:05	.64	0:05	4.54	0:34
London	.77	0:07	.80	0:07	4.02	0:34
Madrid	.87	0:11	.96	0:13	9.09	1:59
Mexico City	.41	0:22	.41	0:22	6.61	6:01
Ottawa	1.18	0:07	1.29	0:08	7.64	0:46
Pretoria	.59	0:29	.67	0:33	3.00	2:26
Seoul	1.18	0:30	1.75	0:44	6.89	2:54
Tokyo	1.19	0:06	2.14	0:12	12.08	1:05
Wash., D.C.	.63	0:04	1.46	0:09	7.61	0:45
Your Store	_____	_____	_____	_____	_____	_____

Taken from: *Agriculture Trade Highlights*, June, 1990.

To calculate how long on average a person would work to buy one kilogram of sirloin steak in Mexico City:

1. Divide price of steak by hourly wage to get total hours worked ($\$4.78 \div \$1.10 = 4.345$ hours).
2. To convert part of hour (.345) to minutes, multiply by 60 ($.345 \times 60 = 20.7$ or 21 minutes).

Total time worked: 4 hours, 21 minutes

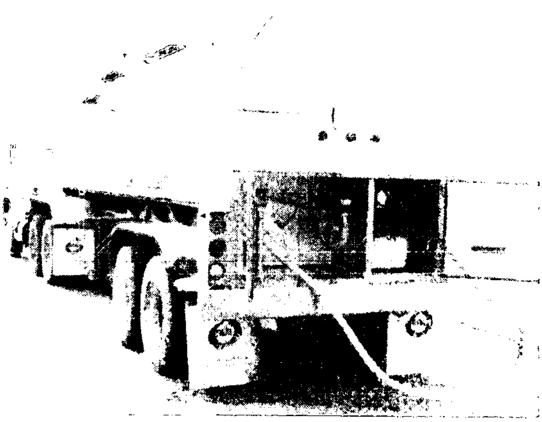
Why do Americans enjoy a relatively cheap food supply? The United States government places a high priority on agricultural education and research to increase agricultural productivity and assure an adequate food supply at acceptable prices. In 1862, the U.S. Congress passed the Morrill Land-Grant Act promising each state a funded endowment for a college of practical education in agriculture and engineering. In 1887, the Hatch Act provided each state some financial support to conduct original research bearing directly upon the agricultural industry of the United States. The facilities to support this research are known as agricultural experiment stations. In 1914, the extension service was established to provide educational programs that communicate practical applications of this research to farmers and many other special interest groups. Investments in research, education, and extension in the United States have generated advances in technology that have resulted in one of the most modern, efficient agricultural systems in the world. Those investments brought about revolutions in agriculture.

REVOLUTIONS IN AGRICULTURE —

Mechanization has revolutionized many labor-intensive farm operations. One good example is the dairy industry. With today's technology, one person can milk 12 cows in about 15 minutes. It would take two people over one hour to milk the same cows by hand. Modern dairy operations pipe fresh milk directly to refrigerated tanks. Since milk is never exposed to the air, bacterial numbers are low and milk quality is high. The milk is picked up in tank trucks daily and delivered to processers who pasturize, package and deliver it quickly to retail stores. They provide us with fresh, safe, low-cost milk and dairy products (cheese, yogurt, ice cream, butter, etc.).

On a modern grain farm, growers can harvest about 6.5 acres of corn in one hour. A combine strips ears of corn from the stalks and removes the kernels (shelling). The corn is hauled by trucks to an automatic dryer (similar to a clothes dryer) located on the farm. The corn is dried (so it will not mold and rot) and is stored in grain bins. One hundred years ago, farmers would have walked down the rows of corn, pulled off the ears and thrown them in a wagon. The ears of corn were then stored in large wooden buildings.

Chemicals have greatly improved farmers' ability to prevent and treat weed and insect invasions of crops. One hundred years ago, a farmer had to remove weeds with a hoe and really had no good way to get rid of insects. If large numbers of either weeds or insects were present in a field, low crop yields and poor quality would result. Fifty years ago, mechanical cultivation did a better job of removing weeds than hoeing by hand but did not get rid of insects. Today, a farmer can kill weeds by applying herbicides and kill damaging insects by applying insecticides. Thus, modern farmers can [illegible]t and control pest problems much like physicians prevent and control [illegible]s with pharmaceutical products.



Top left, modern milking parlor; lower left, tank truck receiving milk from refrigerated holding tank; right, dairy food section of supermarket.

Improved genetics from research by scientists in private industry, government and at university experiment stations has benefitted farmers.

Plants have been bred to increase yields (number of bushels per acre). Yields that are common today were unimaginable even 30 years ago. In 1960, the average corn yield in the United States was 63 bushels per acre. In 1989, the average was 119 bushels per acre. This phenomenon was created by careful, selective breeding of corn plants with exceptional characteristics such as higher yield response to fertilizer, stronger stalks, or improved nutritional quality.

Higher-quality animals (more protein, less fat) have been produced by the same careful selection and cross-breeding. This has resulted in more milk per cow, more and leaner meat per beef animal or pig, and more eggs per hen.

CHANGES RESULTING FROM USE OF NEW TECHNOLOGY

Increased productivity — Many, many technological changes in agriculture have occurred over a relatively short period of time (75 to 100 years). For example, farm labor productivity (output per farm worker) has increased twelve-fold since the 1920s. Machinery has replaced back-breaking labor, thus increasing farm worker safety and productivity. At the same time, crop yields have increased 2.5 times while crop acres have remained essentially the same.

Fewer but larger farms — The number, size, and management of farms have changed. The number of farms has declined from over six million in the 1920s to about two million today. During this same time, the total number of crop acres actually farmed has remained about the same (375 million), but the size of farms has more than doubled. Farm population (number of people living on farms) has declined as well. During the Great Depression (1930s), nearly ¼ of the entire U.S. population lived on farms. The farm population today is only two percent of the total U.S. population.

The resulting economic and social adjustments have often been very painful for farm families. However, reduced labor demands have offered opportunities to pursue special interests and activities that time did not permit before. Because of these technological advances, many farmers and/or their children have moved to cities. Some have had to learn new skills and train for different jobs. Some have found jobs related to farming: e.g., developing new technologies (scientist); food processing (engineer, manager); selling (marketing or serving food); or designing and building

Above, unloading wagon of ear corn to an engine-powered elevator (probably 1930s); today's modern combine picks, shells and unloads to a wagon in the field.

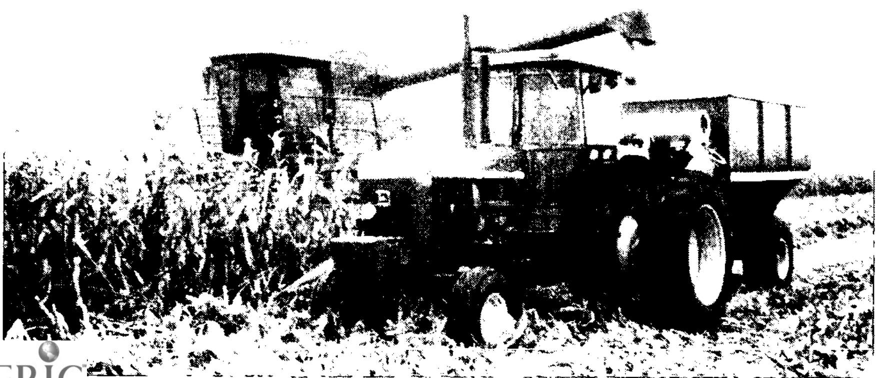
machinery (engineer, technician). Others have pursued professional careers related to agriculture such as vocational agriculture teachers, agricultural lenders, landscape designers, recreational leaders, and forest rangers. Still others have chosen jobs as factory employees, journalists, mechanics, carpenters, retail clerks and many others. Most of the people who used to live on farms have productive jobs that contribute to growth in our national income (GNP), providing everyone with a higher standard of living (including the two percent who continue to live and work on farms).

Concurrent changes — Consumers are a very powerful influence in American society as their tastes, preferences and economic well-being influence their demand for goods and services. Manufacturers of cars, electronic equipment and even food products must respond to what consumers want and are willing and able to pay for. In the United States, healthier life styles (exercise and diets) continue to be popular and influence consumer food demand. The meat-packing industry has responded by trimming excess fat and paying farmers for producing leaner animals. Beef and pork producers have responded by improving animal nutrition and selectively breeding for leaner animals. Food manufacturers process and package foods in new ways to satisfy changes in consumers' life styles, e.g., away-from-home eating in fast-food restaurants or microwave cooking in their homes.

NEWER TECHNOLOGIES

Even newer technological developments (including biotechnology) will soon be available to agriculturalists and will provide additional technologies, promising even more efficient ways to produce plant and animal products. As a student of economics and business, you know that, to be competitive, a producer must develop a product or service that the consumer will buy. To remain profitable and competitive, the producer must keep costs low.

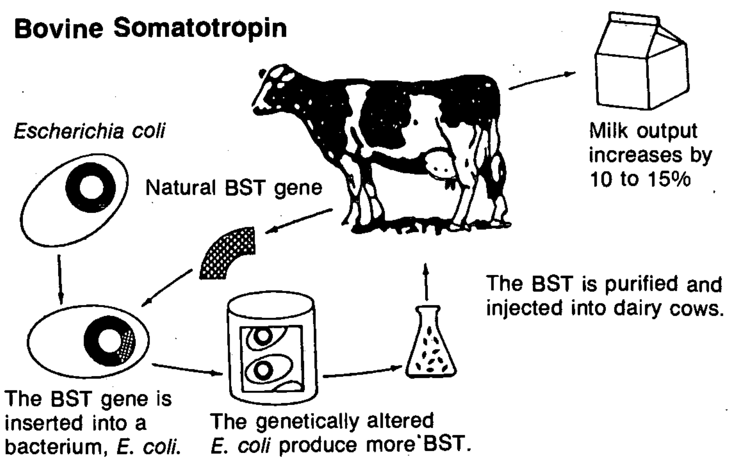
Plants — With traditional breeding techniques, plants are selected for



desired traits and crossed with other plants that have desirable traits. The results of these crossings are often uncertain. For example, corn plants with large ears can be crossed with corn plants that have strong stalks (resistant to wind damage). However, the strong corn plants with the large ears may have a very low tolerance to dry weather. Therefore, if there is little rain during a growing season, the plants may die or not produce full ears of corn. New technologies will allow a scientist to generate new plants which exhibit a specific trait due to the presence of a specific gene (hereditary unit). Traditional breeding techniques might be considered a shotgun approach: some desired traits (genes), plus some traits (genes) with undesirable characteristics. Biotechnology will allow a scientist to use a rifle approach: select a single desirable trait and insert the gene for that trait into cells of the plant without introducing other genes that may not have desirable traits.

Biotechnology in plant science has been used to produce plants that are insect resistant. The Bt-toxin gene comes from the bacteria *Bacillus thuringiensis* which is currently being used in vegetable crop dusts by gardeners. This gene is responsible for producing a toxin that kills caterpillars when they eat a plant containing the Bt-toxin. Scientists have transferred this gene from bacteria into tomato plants. The plants produce the toxin so that when caterpillars eat the plants, the toxin kills them and the plants continue to grow and yield more tomatoes. Currently, the Bt-toxin gene also is being transferred into potato, tobacco and cotton plants. Scientists expect to insert the gene into other major field crops such as corn, wheat, rice and soybeans.

Professor Thomas Hodges at Purdue University's School of Agriculture has made a major breakthrough in plant genetic engineering. He has developed a method for inserting a desired gene into one cell from a rice



 e 2. Process for producing Bovine Somatotropin.

plant by briefly creating holes in the cell membrane with an electric shock treatment. After the rice plant grows from the one cell and the seeds are harvested, the seeds will have the new gene. Hodges may soon be able to use this technique on corn as well. Rice is a food crop eaten by well over half of the people in our world, and corn is an important grain for animal feed. This important work by Professor Hodges has helped to establish Purdue's pre-eminence in plant biotechnology.

Animals — New products that will increase the efficiency of producing pork and milk will soon be available. These biotechnology products will cause animals to produce more lean meat or milk with less feed.

The first biotechnology products that are likely to have a major impact on the food animal industries are *somatotropins*. Somatotropin is a protein hormone (quite different from steroid hormones) secreted in very small amounts by the pituitary gland of all mammals. This hormone regulates growth and lactation in animals. Each species produces its own type of somatotropin [e.g., cattle produce bovine somatotropin (BST)]. Through genetic engineering, bacteria can be used to manufacture BST commercially, as is insulin for treatment of diabetes. Figure 2 illustrates how bovine somatotropin is produced which, when injected into cows, causes milk production to increase and helps dairy farmers reduce their production costs.

Somatotropin is naturally secreted by **every** cow. And, there is **no more** somatotropin in milk produced by injected cows than there is in milk from cows that have not had BST injected. Since milk from treated and untreated cows is identical, the milk from treated cows is completely safe. BST will probably be approved by the Food and Drug Administration (FDA) for use by dairy farmers sometime in 1991.

Porcine somatotropin (PST), a somatotropin produced by hogs, is awaiting FDA approval and should be available soon. Somatotropin encourages growth of muscle (meat) rather than fat. It also helps animals grow faster on less feed. This will decrease production costs for pork producers and offer consumers lower-priced, leaner pork.

Another product that has been developed and also is awaiting FDA approval is ractopamine. This new product can be added to hog feed (rather than injected). It produces results similar to PST, i.e., more lean meat, less fat, increased feed efficiency, and lower production costs. As a feed additive, ractopamine use may be more practical than the daily injections or monthly implants necessary with PST.

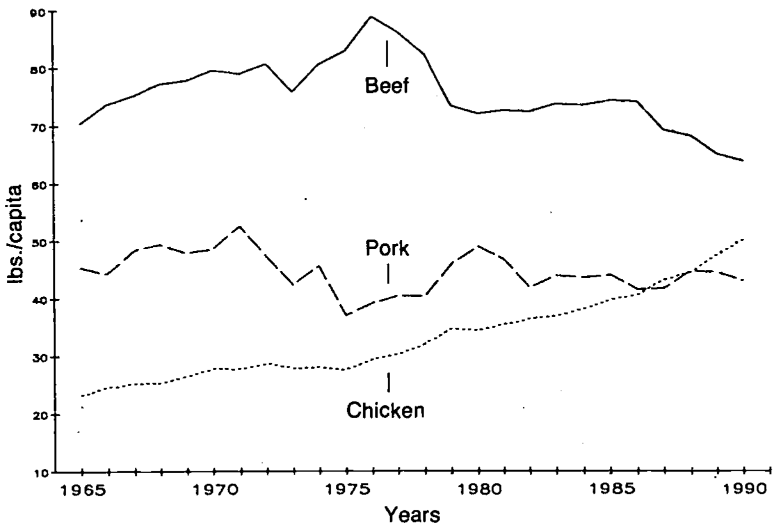
ECONOMIC EFFECTS FOR THE PRODUCER AND CONSUMER

As you know from studying economics, the goal of any firm is to "maximize [illegible]" (produce the highest quality product at the lowest possible cost). The [illegible] livestock producers should be to maximize profits per unit of time, since [illegible]nd facilities can be used year-round, unlike crop production which is seasonal. The new hog production technologies, PST and ractopamine, are expected to increase hog producer profits due to:

- Increased feed efficiency (pounds of pork per pound of feed eaten by the animal). This benefit translates into lower feed costs.
- Improved rate of gain (average number of pounds gained per day). Hogs that grow faster go to market sooner allowing the producer to make more profit per unit of time, e.g., per year.
- Less fat and more lean meat. This means a higher-valued hog at the slaughter plant, thus more profit for the producer and processor. For the consumer, it means cheaper, higher-quality pork.

Total meat consumption in the United States has grown slowly. The average consumer has reduced beef purchases and increased poultry purchases (Figure 3). The substitution of poultry for red meat came in response to a reduction in chicken prices relative to prices of beef and pork. Actual and perceived nutritional and health concerns also have contributed to these changes in red meat and poultry consumption.

Figure 3. Per Capita Consumption of Beef, Pork, and Chicken 1965 - 1990



If pork producers can convince American consumers that pork produced with the new technologies is nutritious and lower in fat and cholesterol, pork is likely to regain some of its "market share" that was lost to chicken.

Livestock producers compete against each other. Broiler (chicken grown for meat) growers compete against hog and beef producers for the consumers' "meat dollar" just as manufacturers of Aim, Colgate and Crest ...ebrough Ponds, Colgate-Palmolive, and Procter and Gamble respective-... ompete for the "toothpaste dollar." You may have seen ads on television that promote real people who eat "real meat— beef," or "pork: the other white meat," or who "get a kick out of milk." These advertisements are not free. The beef, pork and dairy associations buy air time (with funds raised by assessing producers) to encourage consumers to purchase their products.

These emerging technologies have important *micro economic* implications for the animal industries and consumers. For example, supply and demand curves can illustrate the determination of the pork price and quantities produced and consumed. The effect that the adoption of ractopamine might have on consumer pork expenditures and hog prices can be shown graphically.

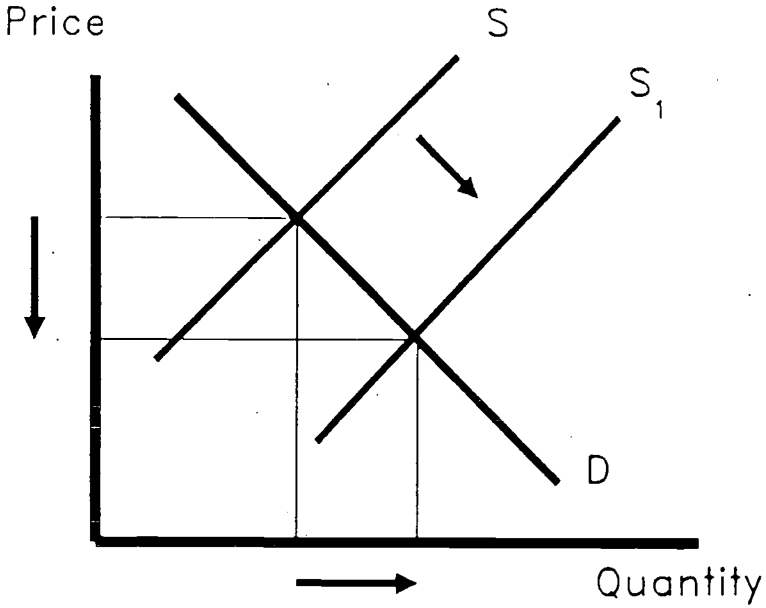


Figure 4. Supply curve shifts to the right (S to S_1) as hog farmers adopt a technology that reduces production costs.

If hog producers adopt ractopamine, they can produce pork with less feed, labor, and other production expenses. As the cost curves (average variable cost, average total cost, and marginal cost) of the various pork producers shift downward and to the right in response to lower production costs due to the increased efficiency associated with ractopamine use, the pork industry supply curve shifts to the right (from S to S_1) as producers expand hog production. Consequently, the price of pork falls and the quantity demanded by consumers increases.

What economic benefit does this technology have for the pork producer? Increases in lean pork production at lower cost "shifts" the pork supply curve to the right and reduces the price producers receive. "Wait a minute," you say. "Is that a benefit?" The earlier adopters who reduce their production costs and produce pigs more efficiently with ractopamine use will continue to receive the higher price, allowing them to earn an extra profit. However, over time, the pork price will fall and the profits gained by the early adopters will tend to fall back to previous levels just as newer technologies emerge which will allow producers to further reduce production costs and retain profits.

Will there be a benefit for consumers? The graph shows a definite benefit for consumers. They will be able to purchase more and leaner pork at a lower price!! Will the pork industry regain some of the consumer's "meat dollar?" Yes, the pork producers will get a greater share of consumers' total meat expenditures as pork prices fall relative to beef and chicken prices.

Economic concepts can be used to analyze effects of other technologies as well. For example, economists can research the economic effects on producers and consumers of insect or drought resistant crops either before or after the new varieties become available.

SUMMARY

Economics offers powerful theoretical and practical tools to analyze the economic consequences of new agricultural technology adoption. Data bases, computers, and advanced communication systems provide ways to accurately analyze and quickly share the results of economic studies with farmers, agribusiness leaders, government policy makers, food processors, managers of grocery stores, and consumers.

Also, a better understanding of agricultural economic concepts can help Americans become better food buyers, be more knowledgeable of food values, and appreciate their relatively cheap, high-quality food supply.

"If I am interested in this topic, are there career opportunities?"

Yes, there are widespread opportunities for professionally-trained business people and economists to research, analyze, manage, and communicate technological advances. Trained agricultural economists live in large cities and small towns and work for large corporations, small businesses, universities, state and federal government, radio and television stations, and professional organizations. They develop new markets and sell products; manage businesses; analyze markets and prices; research new technologies and write and teach about them. In fact, agricultural economists find a multitude of opportunities for employment in the food, agricultural and natural resource systems in the United States and in countries throughout the world.

Marshall A. Martin is a Professor of Agricultural Economics and Director of the Center for Agricultural Policy and Technology Assessment in Purdue's School of Agriculture. Professors, research associates and students associated with the Center evaluate the economic ramifications of new agricultural technologies. The primary mission of the Center is to conduct multi-disciplinary research on economic and social issues related to these scientific discoveries. Information and ideas generated by the Center can provide the basis for policy formation and business decisions.

Professor Martin also teaches undergraduate and graduate courses and is an extension specialist. He conducts research and writes and speaks extensively on international and U.S. agricultural policy and technology assessments. Internationally known as a writer and lecturer in three languages, Martin is especially knowledgeable about agriculture in the Iberian Penisula and Latin America where he lived and worked for many years.

The technical and professional assistance given by Professor Martin for this publication is greatly appreciated.

PROJECTS:

I. Go to your local grocery store. Price the same products that appear in Table 1 of the text.

A. A secretary in Indianapolis makes $320 per week. Based on a 40-hour week and the prices you find in your store, reconstruct Table 1 and calculate how long it will take this secretary in Indianapolis, Indiana to purchase these food items.

B. If you have a job, calculate how long you work to purchase each item.

II. Go to the library and find a world atlas. Locate each city listed in Table 1 of the text and name the country in which it is located.

City	Country
Bern	____________
Brasilia	____________
Buenos Aires	____________
Canberra	____________
London	____________
Madrid	____________
Mexico City	____________
Ottawa	____________
Pretoria	____________
Seoul	____________
Tokyo	____________
Washington, D.C.	____________

QUIZ:

MULTIPLE CHOICE — Circle the letter of the most appropriate answer for each of the following.

1. What percentage change has there been in corn yields in the United States between 1960 and 1989?
   A. 8.8% increase
   B. 88.8% decrease
   C. .888% increase
   D. 88.8% increase

2. What impact can we see today as a result of the Hatch Act of 1887?
   A. Cheaper food prices for U.S. citizens
   B. Higher yielding corn varieties
   C. Increased feed efficiency (e.g., more meat, milk and eggs per pound of feed consumed)
   D. All of the above

3. Which of the following jobs could be an agricultural career?
   A. Biochemist
   B. Journalist
   C. Economist
   D. Commodity broker
   E. Legislator
   F. Grain farm manager
   G. All of the above

4. Some of the newest technological advances described in the text are biotechnology developments. Which of the following technologies is an example of biotechnology?
   A. Inserting specific genes into cells to alter offspring and create higher quality plants and animals
   B. Computer software to make mathematical calculations faster and more accurate
   C. Machines that harvest grain faster
   D. Ammonium nitrate for use as fertilizer
   E. All of the above

5. Using the supply and demand curve (Figure 4) in the text, what would happen to future pork prices if the use of ractopamine is not approved by the Food and Drug Administration and the U.S. population and per capita income (GNP per person) continue to increase?
   A. increase
   B. decrease
   C. no change
   D. insufficient information

6. Assuming it costs a farmer $100 to produce a 250-pound pig and the pig can be sold for $0.50 per pound
   A. the cost per pound is $0.40.
   B. the profit per pig is $25.00.
   C. the profit per pound is $0.10.
   D. all of the above are true.
   E. none of the above are true.

7. What is the expected level of BST in milk from cows injected with BST compared to those not injected with BST?
   A. Higher
   B. No difference
   C. Lower
   D. Depends on the dosage of BST injected

In 1950, there were 23 million farmers and 150 million Americans. Today, there are 5 million farmers and 250 million Americans.

A. Over the last 40 years, the number of farmers in the United States has increased by 78%.
B. Farmers today represent about 15% of the U.S. population.
C. Farmers today represent about 2% of the U.S. population.
D. None of the above are true.

9. In 1980, the real value (adjusted for inflation) of farm production was $111 billion and there were 3.7 million people employed in farming. In 1989, the real value of farm production was $133 billion and there were 2.8 million people employed in farming.
   A. The real value of output per farm worker in 1980 was $30,000.
   B. The real value of output per farm worker in 1989 was $47,500.
   C. From 1980 to 1989 real output per farm worker increased approximately 58%.
   D. Over the ten year period (1980-89), average farm labor productivity increased by about 5.8% per year.
   E. All of the above are true.

10. Based on trends in meat consumption (Figure 3 in the text),
   A. per capita chicken consumption will surpass per capita beef consumption by 1993 if current trends continue.
   B. beef consumption reached a peak in 1976.
   C. per capita poultry consumption doubled from 1965 to 1990.
   D. in 1980, pork consumption was about 50 pounds per capita.
   E. all of the above are true.

11. Technological advances in U.S. agriculture have
   A. mostly benefitted consumers.
   B. benefitted late compared to early adopters.
   C. resulted in an increase in crop acres.
   D. caused both the number and size of farms to decline.

ANSWERS:

I. This secretary makes $8.00 per hour. Use the calculation example in the footnote of Table 1 to calculate each of the food items priced in your store.

II. Switzerland, Brazil, Argentina, Australia, England, Spain, Mexico, Canada, Republic of South Africa, Korea, Japan, United States.

1 D; 3.-G.; 4.-A; 5.-A; 6.-D; 7.-B; 8.-C; 9.-E; 10.-E; 11.-A.

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Purdue University
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Printed Name: MARY A. WELCH	Organization: School of Agriculture
Address: 1140 AGAD Purdue University W. Lafayette, IN. 47907-1140	Telephone Number: (317) 494-8470
	Date: 10-2-96

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