THE AGRICULTURAL RESEARCH CENTER
OF THE UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL HANDBOOK No. 43
## DIRECTORY FOR VISITORS

<table>
<thead>
<tr>
<th>Representative</th>
<th>Building</th>
<th>Room</th>
<th>Telephone</th>
<th>Extension</th>
<th>Agency Represented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glen Briggs</td>
<td>Administration Building</td>
<td>351A</td>
<td>REpublic4142</td>
<td>4589</td>
<td>Agricultural Research Administration.</td>
</tr>
<tr>
<td>P. M. Gilmer</td>
<td>EPQ Building A</td>
<td>201</td>
<td>Tower 6430</td>
<td>371</td>
<td>Entertainment and Industrial Chemistry.</td>
</tr>
<tr>
<td>Roy C. Jones</td>
<td>Center Building</td>
<td>121</td>
<td>Tower 6430</td>
<td>438</td>
<td>Production and Marketing Administration:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Federal Seed Act.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grain Standards Research and Testing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Livestock Branch, Insecticide Division.</td>
</tr>
<tr>
<td>John H. Martin</td>
<td>South Building, Plant Industry Station</td>
<td>129</td>
<td>Tower 6400</td>
<td>544</td>
<td>Agriculture and Industrial Chemistry.</td>
</tr>
<tr>
<td>Mrs. Zelta F. Rodenwold</td>
<td>Center Building C</td>
<td>119</td>
<td>Tower 6430</td>
<td>398</td>
<td>Human Nutrition and Home Economics.</td>
</tr>
</tbody>
</table>
CONTENTS

The Agricultural Research Center .................................................. 1
What It Is .................................................................................. 1
Where It Is ............................................................................... 2
How To Get There ....................................................................... 2
Visitors Welcome ......................................................................... 2

Bureau of Agricultural and Industrial Chemistry ..................... 3
Cooperative Work on Plant-Growth Regulators ....................... 3
Antibiotics From Higher Plants .................................................. 3

Bureau of Animal Industry ................................................................. 5
Production of Farm Animals ....................................................... 5
Animal Nutrition .......................................................................... 5
Research With Cattle ..................................................................... 6
Progress in Swine Research .......................................................... 8
More Productive Sheep and Goats ............................................. 9
Animal Fiber Work ........................................................................ 10
Meat Research ............................................................................ 10
Better Poultry and Eggs ............................................................... 11
The Beltsville Small White Turkey ............................................. 11
Livestock Diseases Attacked by Science .................................... 13
Strategy Against Livestock Parasites ......................................... 13

Bureau of Dairy Industry ................................................................. 15
Building Better Dairy Herds ....................................................... 15
The Dairy-Anatomy Puzzle .......................................................... 18
Dairy Cattle Nutrition and Management ............................... 19
Cheese Making ............................................................................ 21

Bureau of Entomology and Plant Quarantine ............................. 22
Studying Insect Problems ............................................................ 22
Controlling the Insect .................................................................. 23
Decreasing Insect Contamination ............................................. 25

Bureau of Human Nutrition and Home Economics ................ 27
Serves Homes and Families ....................................................... 27
Solves Canning and Freezing Problems ................................. 27
Devises Cookery for Old and New Foods ................................ 28
Contributes to School Lunch Programs ..................................... 28
Determines Food Values and Needs .......................................... 29
Bureau of Human Nutrition and Home Economics—Continued
Works Out Food Budgets ............................................................ 31
Discovers Facts About Fabrics ................................................... 31
Provides Guides for Clothing Selection ..................................... 32
Designs Functional House Plans ............................................... 33
Analyzes Household Equipment ............................................... 34

Bureau of Plant Industry, Soils, and Agricultural Engineering ... 35
New and Improved Plants ............................................................ 35
Better Vegetables, Fruits, and Flowers ...................................... 35
Field Crop Development .............................................................. 37
Cold-Storage Experimentation ..................................................... 38
Chemicals and Lights Regulate Plant Growth ......................... 38
Drug Garden and Fungus Collections ........................................ 38
Soil Surveys .............................................................................. 39
Research With Radioactive Chemicals ...................................... 39
Agricultural Engineering Studies .............................................. 40
Forage Crop Preservation ............................................................ 41
Ultraviolet Radiation on Poultry ............................................... 41
Development of Automatic Egg Candling ................................ 41
Higher Than Sound ..................................................................... 41
Improving Farm Machinery ....................................................... 42

Fish and Wildlife Service of the Department of Interior ........ 43
Farming and Wildlife ................................................................. 43

Forest Service ............................................................................ 44
Forest Research and the Experimental Forest ......................... 44

Production and Marketing Administration ............................. 45
Testing Commercial Insecticides and Other Killers ............... 45
Grain Standards Research ............................................................ 45
Testing Miscellaneous Commodities ....................................... 45
Insuring Seed Quality ................................................................. 46
Aerial Photographic Negatives .................................................. 47
School Lunch and Plentiful Foods ............................................ 47
Soil Conservation Service ............................................................ 48
Soil and Water Conservation .................................................... 48

III
AGRICULTURAL research has transformed American agriculture in the space of a lifetime. Discoveries by scientists of the United States Department of Agriculture, the State agricultural experiment stations, and private industry have helped to make possible the growth of the entire Nation. Work done at the Agricultural Research Center has contributed immensely to this progress.

To a farmer, agricultural research means new varieties of crops that thrive better and yield higher quality products, superior breeds of livestock, improved feeds, better control of diseases, insects, and weeds, more intelligent use of soils and forests, and improved methods of marketing and distribution. All this adds up to increased efficiency.

To the Nation, agricultural research means assurance of ample supplies of food and fiber and a higher standard of living for everyone.

Agricultural research benefits all the people of this country and even those of distant lands. No estimate can be made of the number of human lives that have been saved by penicillin, made possible by mass-production methods developed by agricultural scientists. People everywhere know how DDT controls insects that transmit diseases to humans. These are but two of the many contributions of agricultural research to human welfare.

Byron T. Shaw

Administrator, Agricultural Research Administration.

June 1, 1952, Washington, D. C.
The Agricultural Research Center

WHAT IT IS

The Agricultural Research Center is a part of the Agricultural Research Administration (ARA) of the United States Department of Agriculture. All the bureaus within the ARA do a part of their research at the Center. These are the Bureaus of Agricultural and Industrial Chemistry; Animal Industry; Dairy Industry; Entomology and Plant Quarantine; Human Nutrition and Home Economics; and Plant Industry, Soils, and Agricultural Engineering. Other Department of Agriculture agencies that carry on research at the Center are the Forest Service, the Production and Marketing Administration, and the Soil Conservation Service.

A few other units of the United States Government conduct research at the Center—the Bureau of Standards of the Department of Commerce, the Geochemical Prospecting Unit of the Geological Survey of the Department of Interior, and the Veterinary Section of the Food and Drug Administration of the Federal Security Agency. Adjoining the Research Center is the Patuxent Research Refuge, where the Fish and Wildlife Service of the Department of Interior carries out studies of wildlife problems that relate to agriculture.

Agricultural research at the Center deals mainly with broad problems of national interest. Much of it is basic or fundamental research, with the goal of accumulating scientific information that can be applied elsewhere. Often two or more bureaus of the ARA work together, combining the talents and experience of several groups of specialists. Many of the projects are carried on in cooperation with one or more State experiment stations. This strategy of consolidated attack on research problems has led to countless discoveries that have brought American agriculture to its present high level.

When thoroughly proved, results of all investigations are made available to the public through the Agriculture Department's Office of Information in Washington, D. C.

At present the Agricultural Research Center covers about 11,000 acres (1 acre equals 2.471 hectares). Besides experimental pastures, ranges, orchards, gardens, fields for cultivated crops, timber stands, and soil-treatment plots, there are 950 buildings, equipped to meet the needs of special kinds of research or to provide office and laboratory space for the approximately 2,000 persons who work there. About half of these workers are scientists—agronomists, animal husbandmen, apiculturists, architects, bacteriologists, biochemists, biologists, botanists, chemists, dairy technologists, engineers, entomologists, geneticists, grain technologists, helminthologists, home economists, horticulturists, mycologists, nematologists, nutritionists, parasitologists, pathologists, physicists, physiologists, statisticians, veterinarians, and zoologists. The others are clerical, maintenance, and farm workers.

Among the Center's buildings are 58 laboratories, 31 greenhouses, 161 barns and storage buildings, 700 small-animal and poultry houses, shops, an apiary, a granary, a warehouse, and heating, water-treatment, and sewage-disposal plants.

There are nearly 3,000 experimental farm animals at the Center, more than 10,000 mature laying and breeding fowls, and about 5,500 small animals for use in laboratory tests. The dairy herd of 500 cattle consists mainly of Holsteins and Jerseys, with a small number of crossbreds and dual-purpose cattle. Other animals include sheep, hogs, and goats.
WHERE IT IS

The Research Center is near Beltsville, Md., 15 miles northeast of Washington, D. C. It occupies two separate tracts on opposite sides of the Washington-Baltimore Boulevard, U. S. Route No. 1. On the northwest side of the highway, 2½ miles beyond the University of Maryland, is the Plant Industry Station, headquarters of the Bureau of Plant Industry, Soils, and Agricultural Engineering. About a mile farther, on the east side of the highway, is the larger tract, site of the other activities of the Center. The map in the middle of this pamphlet indicates the layout.

HOW TO GET THERE

The best way for an individual or a small group to see the Center is by automobile, because many of the buildings are some distance from the road. Large groups frequently engage a bus. When this is done, ARA supplies a guide to describe the activities of the Center.

The Center may also be reached by both Greyhound and National Trailways buses, which stop at the Plant Industry Station and at Beltsville. Two special Greyhound buses leave the terminal at Twelfth Street and New York Avenue NW., in Washington, at 7:10 a.m., Monday through Friday, arriving at the office of the Superintendent of the Center at 7:55 a.m. This office is 2 miles from the regular bus stop at Beltsville.

VISITORS WELCOME

Those interested in research to improve farming and farm living are always welcome at the Agricultural Research Center, where a small staff is available to explain the work in progress. As many as 10,000 persons visit the Center each year. In 1951, visitors came from all the States and three of the Territories of the United States and from 80 foreign countries.

Visitors who wish to consult research specialists at the Center should make appointments by telephone or by mail, through the designated representative of the Agricultural Research Administration in Washington, D. C. The Animal Disease Station can be visited only by appointment, since infectious diseases are studied there. Because of certain disease-control programs, visits to the dual-purpose cattle breeding herd can be made only by appointment.

There are cafeterias at the Research Center and at the Plant Industry Station where luncheon is served. Arrangements for group tours include reservations for luncheon.

This pamphlet is intended as a general guide. There is a directory for visitors inside the front cover. Brief descriptions of the work being done at the Center follow.
Bureau of Agricultural and Industrial Chemistry

COOPERATIVE WORK ON PLANT-GROWTH REGULATORS

Application of organic chemicals to plants to produce modifications in the rate and type of growth is now widely practiced. Examples are the use of the compound 2,4-D to kill broad-leaved weeds without injuring desirable grasses, and of naphthaleneacetic acid to prevent premature drop of apples. It is known, however, that in some cases these chemical plant-growth regulators produce undesirable as well as desirable effects on plants. Studies are under way to learn more about these effects. Chemists of the Bureau's Division of Biologically Active Chemical Compounds synthesize the plant-growth regulators, and plant physiologists of the Bureau of Plant Industry, Soils, and Agricultural Engineering apply them to growing plants.

The entry of these chemicals, passage through the plant, and final location in the plant have been accurately determined by using radioactive tracer techniques. Through this work it has been demonstrated for the first time that growth regulators of the 2,4-D type are actually absorbed by the plant and are transferred to the part that is developing most rapidly at the time of application. These substances at certain concentrations inhibit the growth of broad-leaved plants (dicotyledons) but do not affect the growth of grasses (monocotyledons) to an appreciable degree. This difference is due to differences in the manner in which the plant constituents react to the compound.

Preliminary reports indicate that the killing power of 2,4-D on broad-leaved plants can be controlled. This may be possible through use of 2,4-dichlorophenoxyacetyl derivatives of D-amino acids, such as D-aspartic, D-phenylalanine, and D-methionine, which at low concentration do not have the killing power of 2,4-D. For example, it has been possible to bring about fruit set without causing injury to the tomato plant by spraying with these compounds at the time of flowering, which would not be possible with 2,4-D. It appears that these and related compounds may find wide application in agriculture. In contrast to the D-amino acid derivatives, the 2,4-dichlorophenoxyacetyl derivatives of L-amino acids retain the killing power of 2,4-D at low concentration.

ANTIBIOTICS FROM HIGHER PLANTS

Although the term "antibiotic" is of recent origin, chemical substances from plants, in one form or another, have been used for the treatment and cure of diseases for centuries. An antibiotic may be defined as an organic chemical substance, produced by a plant, an animal, or a micro-organism, which selectively inhibits the growth of or completely destroys bacteria, viruses, fungi, or other disease-producing organisms.

Plants are a potentially rich source of antibiotics. In a survey conducted by the Division of Biologically Active Chemical Compounds, approximately 40 percent of the extracts from higher plants tested exhibited either antibacterial or antifungal
activity or both. Representative micro-organisms of several types have been used to test the potency of various plant extracts. Among the plants or plant parts whose extracts show promise of being good sources of antibiotics are the sweetpotato plant and tubers, cabbage, bananas, cacti, lettuce, celery, cucumber, broccoli, and muskmelon. A great need exists for additional antibiotics with wider ranges of activity and of low toxicity to man. Perhaps chemical substances isolated from agricultural sources will supply part of the need.

One such antibiotic having antifungal activity has been isolated from the tomato plant. This material has been appropriately named tomatine. Tomatine has been characterized as a new glycosidal alkaloid which upon acid hydrolysis yields an aglycone portion, tomatidine, and a carbohydrate fraction consisting of one molecule each of xylose and galactose and two of glucose. Tomatidine and one of its degradation products, designated dihydrotomatidine, have antifungal activity. Tomatidine has also been identified as a new steroidal secondary amine, and it has been successfully degraded to a sterol (pregnene derivative) which can be transformed into sex hormones and other biologically active sterols.

A biochemist in a Research Center laboratory examines two batches of pure crystalline tomatine.
The economical production of livestock products has become increasingly important. The growing world population, coupled with unsettled world conditions, emphasizes the need for more intensive animal production and demands greater efficiency in farm and livestock production practices. Improved methods of animal breeding and feeding will provide great opportunities for meeting many of the current needs for food and clothing.

Fundamental animal nutrition research is carried on at the Research Center with swine, beef and dual-purpose cattle, sheep, and goats. Biochemical, microbiological, chemical, and physical analyses of feedstuffs and animal tissues and products are carried out in laboratories equipped with modern apparatus for making spectrophotometric and spectrographic analyses, radioactive isotope studies, and other chemical and physical determinations.

Each year, series of experiments with white rats are conducted and correlated with nutritional problems being studied with farm animals. Special emphasis is placed on vitamin, mineral, and protein utilization and requirements. Biological assays with white rats are in progress at all times. These involve studies of farm animal feeds and products that are tested for nutritional and growth factors.

Radioisotopes are being used as tracers in studying the nutritional requirements of laboratory and farm animals. Various nutrients tagged with radioisotopes are administered to experimental animals, after which their uptake by various tissues and their excretion are measured. Through the use of radioactive tracers, much basic information relative to the metabolism of the nutrients involved is obtained.

Research in swine nutrition has been directed into a variety of fields. In vitamin studies, major emphasis has been directed at establishing minimum requirements for gestation and lactation in swine and in checking requirement figures which have not been firmly established. This method of attack is being continued in order to fill in the more important and obvious gaps in our current knowledge of vitamin nutrition.

Another major phase of investigation has been a study of nutritional factors that might affect baby pig losses. Female swine have been reared under controlled dietary regimes and carried through two successive gestation-lactation cycles. Measurements have been made of the effects of diets of varying nutritional levels fed to the dams on number, size, vigor, and survival of pigs born, and average weight of pigs at a given age. A direct relationship has been established between inadequate nutrition and baby pig losses, and progress is being made in reducing losses due to faulty nutrition.

Studies are in progress to evaluate the effects of administering varying amounts of hormones on reproductive performance, growth, egg production, and feed efficiency. The studies include investigation of the effect of environmental influences such as temperature and light.
Evaluation of feedstuffs for sheep and cattle is based to a large extent on results obtained in digestion and energy metabolism studies. In these studies an exact record is obtained of the nutrients fed, the nutrients refused by the animal, and the nutrients lost in the feces and urine. The difference between the nutrients fed and those lost through feed refusal or in the feces and urine is the amount left for the production of meat, wool, or milk by the animal. Several of these studies are conducted each year with sheep and include the evaluation of a variety of feedstuffs.

RESEARCH WITH CATTLE

Research with dual-purpose cattle is being carried on with the Milking Shorthorn breed. The general plan is to develop and improve strains within the breed that will utilize relatively large amounts of forage efficiently and at the same time produce beef and dairy products of desirable quality and in satisfactory amounts.

In developing this plan, approximately 275 head of cattle of all ages are maintained. Of these, about 80 head are breeding females. Pasture, home-grown hay, and silage are being utilized as far as possible. An attempt is being made to standardize the rations on the basis of adequate nutrients for reproduction, milk, growth, and fattening—rather than the kind of feed. To utilize forage most efficiently, the young animals are given a growing ration rather than a fattening ration. Steer calves are carried to an older age (2 years), when they will fatten more readily on less grain per pound of live weight than if finished earlier. Two-thirds of the male calves are saved as bulls until they are 300 days old to furnish a wide basis for the selection of calves to be saved as breeders. Approximately one-third of the heifer calves are being fed grain and hay individually from 150 to 300 days of age as a control for comparison with those being raised on pasture and silage. Heifers are assigned to the breeding herds at 17 months of age. All heifers are milked during their first lactation—some of them in cooperators' herds and some at the Center. They are rebred to calve 13 months following birth of first calf.

Four breeding bulls are used at a time with approximately 20 cows assigned to each bull. The bulls are used for approximately 2 years and then retained until their steer progeny are slaughtered and their daughters are tested for milk and butterfat production in their first lactation. Sires proved to be superior on the basis of records of their progeny are put back in the breeding herd for additional use. Studies are being made of the inheritance of various characters associated with beef and milk production, the effectiveness of selection and progeny testing, bucket feeding compared with nursing one or more calves on a cow, effects of castration of male calves at 150 days compared with castration at 300 days of age, use of silage in growing and fattening rations compared with hay, use of pasture in growing rations compared with hay, factors affecting the degree of finish in slaughter animals, and factors affecting the quality and composition of the carcasses.

The average production of Milking Shorthorn cows in the herd has been 5,933 pounds of milk and 229 pounds of butterfat for 141 cows completing a 305-day test for their first lactation with twice-a-day milking. The trend has been for cows with the highest milk yield to produce steers with lower than average carcass grade. However, there have been a few cows with high milk yields and better than average steers. It is hoped that superior strains can be built up from such animals.

In comparison with beef Shorthorn steers formerly kept at the Center, the Milking Shorthorn steers gained as rapidly and efficiently when placed on full feed and fed from 500 to 900 pounds live weight. The Milking Shorthorn steers reached 500 pounds sooner than the beef Shorthorns and thus also reached 900 pounds at a younger age than the beef Shorthorns. They were more rangy than the beef Shorthorns and did not have as high slaughter or carcass grades. A preliminary test
indicates that when carried to an older age and to heavier weights their carcasses are improved so that they make acceptable beef, and, if fed relatively large amounts of forage with correspondingly lower grain feed through most of the growing and early fattening stages, they do it economically.

Experiments were started in 1950 to determine the effects of continuous versus interrupted growth on beef cattle. In these experiments identical twin calves are being used. Identical twins are rare, probably occurring once in 2,000 or more calvings. Geneticists have estimated that each pair of identical twins used in nutrition research gives results that are comparable to a herd of 40 head of less closely related calves. In order to study the effects produced by restricting the intake of various nutrients, one of each pair is kept on a full feed diet that is adequate in all respects. The other is given full feed for a time, and then one essential of the ration is restricted for a scheduled period and age interval, after which full feeding is resumed.

Energy restriction was selected for study in the first experiments. The experiments showed that during the period when the calf is receiving a low-energy ration, the growth rate is slower than normal. However, after full feeding is resumed the calf gains weight rapidly and uses feed economically. Although a longer time was required for energy-restricted calves to reach slaughter weight, there was very little difference in the grade or quality of the meat. In subsequent experiments, it is planned to study the effects of restriction of other nutrients, including protein and phosphorus.

Available information on the protein level in the diet of cattle has been used to establish feeding standards for growth and lactation. There is evidence that protein, either because of inadequate amount, poor digestibility, or other reasons, is an important factor in reproductive failure. Groups of cattle are being fed rations with different levels of protein content to obtain information on the relationship of protein
content of the ration to reproductive failure, the protein requirement of beef and
dual-purpose cattle for normal reproduction, and the effects of protein deficiency on
the growth and development of the calf.

Because of certain disease-control programs, appointments must be made to visit
the breeding herd. However, the steer-feeding experiments ordinarily are open to
visitors during the regular working hours.

Although beef cattle studies at the Center deal only with nutrition, other phases
of research with these animals are carried on by the Bureau at Brooksville, Fla.;
Jeanerette, La.; Miles City, Mont.; Fort Robinson, Nebr.; Fort Reno, Okla.; and
Front Royal, Va.

PROGRESS IN SWINE RESEARCH

Research on hogs is conducted on an area consisting of about 270 acres. The plant
includes a farrowing house, record-of-performance house, feed barn, and 50 colony
houses on individual pastures. A breeding herd of about 200 hogs is maintained, and
approximately 250 litters of pigs are farrowed annually.

Swine-breeding research is directed toward development of new methods by which
hog raisers can produce, most efficiently, the kind of pork products most consumers
prefer. Since housewives are demanding more lean cuts of pork and less fat, swine
producers should raise the kind of meat-type hogs that will meet this demand.
Special attention is given to the effects of different systems of breeding, such as
inbreeding, outcrossing, and crossbreeding, upon such characters as fecundity,
viability, rate of growth, feed efficiency, and carcass quality.

In 1934 the United States Department of Agriculture imported from Denmark
hogs of the Landrace and Yorkshire breeds for the purpose of evaluating their
performance in crosses with domestic breeds to improve carcass quality. Ten inbred
lines of swine have been developed by the Bureau in cooperation with several State
experiment stations. Seven of them were developed at the Center. The lines vary in
amounts of inbreeding, ranging from 30 to 50 percent. They average about 9 pigs
per litter at birth and 6 pigs per litter at weaning. These inbred lines of swine have
been performing well in the feed lot, gaining, on the average, 1.45 pounds daily from
weaning (56 days of age) to 225 pounds live weight, and requiring 350 pounds or
less of feed per 100 pounds gain in dry lot. They reach market weight at 5½ to 7
months of age. The lines are yielding 46.6 to 49.7 percent of their live weight at
slaughter in the five preferred trimmed cuts—hams, loins, bacons, picnic shoulders,
and shoulder butts. The most desirable thickness of back fat is 1½ to 1¾ inches.

Tests are now under way to determine the specific and general combining ability
of the various inbred lines when used in crosses with other inbred lines and with
outbred stocks of the American breeds in producers' herds.

The inbred line of Landrace-Poland China breeding and the inbred line of York-
shire-Duroc-Landrace-Hampshire have attained the status of pure breeds and have
been recorded as the Beltsville No. 1 and Beltsville No. 2 hogs, respectively, in the
Inbred Livestock Registry Association, University Farm, St. Paul 1, Minn. Three
other inbred lines have obtained similar status: The Minnesota No. 1 was developed
at the University of Minnesota by crossing the Landrace and Tamworth breeds. The
Montana No. 1, or Hamprace, which is a cross of Landrace and Black Hampshire,
was developed at the Bureau's station at Miles City in cooperation with the Montana
Agricultural Experiment Station. The Maryland No. 1 resulted from crossing the
Landrace and Berkshire breeds and was developed at Blakeford Farms, Queenstown,
Md., in cooperation with the Maryland Agricultural Experiment Station.

Grazing management tests are being conducted to determine the relative merits
of alfalfa and ladino clover pastures when grazed continuously or on a divided
pasture-rotation basis by growing pigs. The level of protein in the concentrate fed the pigs is also being studied.

Herd management practices, such as vaccination for swine erysipelas and hog cholera, worming, and methods of feeding, are studied to determine their effects upon the general health and vigor of the pig crop as evaluated by pig weight at weaning.

Fundamental research includes studies on requirements of vitamins, antibiotics, proteins, minerals, and other growth-producing factors.

MORE PRODUCTIVE SHEEP AND GOATS

The experimental flocks at the Research Center contain about 650 sheep and 70 goats. Breeding investigations include both selective mating and line-breeding of Hampshire, Shropshire, Southdown, and Delaine Merino sheep and the crossing of these breeds for the development of improved strains and crosses that are adapted to commercial lamb production on the farm.

Progeny testing in both ewes and rams and the careful culling of the less productive family lines have shown that production can be materially increased by these practices in all the purebred lines. Experimental work also has shown that greater commercial lamb production can be accomplished by crossing selected purebred lines than by continued mating within either of the breeds.

A new crossbred flock has been developed by mating Columbia rams with Southdale ewes. The Southdale was originally developed by crossing sheep of the Corriedale and Southdown breeds. These crossbred sheep give promise of becoming a highly productive type of farm sheep.

Studies are being conducted to determine the best type of pasture crops and mixed seedings for the production of maximum feed and continuous growth throughout the pasture season. Birdsfoot trefoil and ladino clover in a mixture with
orchard grass and red clover have shown up well in tests. Emphasis is being placed on early- and late-growing crops in order to shorten the period of winter feeding.

Phenothiazine in a mixture of 1 part to 9 parts salt is kept before the sheep at all times for the control of internal parasites.

Milk goat investigations emphasize nutritional studies with purebred and grade Toggenburg goats for the efficient production of high-quality milk. Only bucks of high-producing lines have been used in this work, and they have greatly contributed to the improvement of the milking standard of the herd.

**ANIMAL FIBER WORK**

At the Animal Fiber Laboratory, wool, mohair, and other animal fibers are analyzed to determine the influence of breed, feed, and management on the quantity and quality of fiber. Two rapid tests of fineness and variability in wool have been developed that expedite the determination of these characters in sheep to be selected for breeding stock.

Matchings of fleeces of individual sheep and Angora goats of known genetic origin and breeding are dry-cleaned, carded, and combed. A study of the characteristics of the fibers of these individual fleeces is made to determine which of them are of most value in the manufacture of fabrics, rugs, and blankets. The laboratory findings are handed on to the breeders of sheep and goats so that they may design their breeding programs with a view to obtaining the characteristics of greatest desirability.

The prenatal and postnatal growth of fibers of sheep, goats, Angora rabbits, and fur animals such as mink and fox is being investigated to determine the relationship of the early development of wool and hair to fineness, density, changes in skin thickness, and pigmentaion. The results obtained from this type of fundamental research serve as working tools in the selection of animals where breeding for improved fibers is an important economic consideration.

**MEAT RESEARCH**

The object of most animal-breeding and management and all meat-processing research is the production of more meat of better quality. To obtain this object, the Bureau maintains at the Research Center a complete pilot-plant laboratory with modern facilities for slaughtering experimental animals and equipment for studies in curing, freezing, and edible byproduct production, augmented by laboratories for chemical, microbiological, organoleptic, histological, and physical evaluation of the product.

Cattle, hogs, and lambs slaughtered in the meats laboratory are measured, cut, and analyzed for physical composition (muscle, bone, and fat ratios). In this way, research workers have established standards for meat-type hogs yielding a large proportion of desirable lean cuts and for better cattle and lamb carcasses. Objective methods of estimating the composition of live animals are being investigated, and methods have already been developed and are being improved for determining the amounts of fat, moisture, and bone in animals.

Studies on palatability also make use of objective techniques, and tenderness and juiciness are measured by mechanical devices and flavor and aroma by statistically controlled taste panels.

Meat curing is studied in rooms providing a wide range of controlled temperature, humidity, and air circulation with a view to improving many of the curing methods now in use, especially by farmers and other small producers such as locker plant operators.
The experimental poultry plant at the Research Center includes 177 acres on which are 4 well-equipped laboratory buildings, 10 large laying houses, 3 long brooder houses, 4 large turkey houses, a shop, and nearly 200 colony houses of various sizes for the experimental flocks and equipment. The poultry buildings have a capacity of approximately 8,000 adult chickens and 1,500 turkeys. Facilities are available for brooding about 13,000 chicks and 2,500 poults. About 150,000 eggs are incubated each year. The experimental flocks are made up principally of Rhode Island Reds, White Leghorns, and New Hampshires.

Several methods of breeding for improvement of egg production are being compared on White Leghorns and Rhode Island Reds. These breeding methods include outbreeding, crossbreeding, and the crossing of inbred lines (hybridization). The average production in the Rhode Island Red and White Leghorn breeds is about 200 eggs for the pullet year. Crosses between selected Leghorns and Rhode Island Reds, with and without previous inbreeding, have given improved viability and have produced from 10 to 25 percent more eggs than the standard breeds.

New Hampshire and Cornish breeds are used in the effort to produce superior meat-production chickens that grow fast, have wide breasts, and are of good market type.

Several years of selection and breeding have developed lines that produce eggs with better interior quality. One line produces eggs with a high percentage of thick white, another with few blood spots, one with strong shells, and one line whose eggs withstand heat deterioration unusually well.

Research on hatchability in chickens and turkeys has disclosed several harmful genetic factors, some affecting the egg, which may be eliminated by selective breeding. Poor hatchability also results from various vitamin deficiencies in the diet of the breeding flock.

An important poultry activity at the Center is the administration of the National Poultry Improvement Plan. More than 66 percent of the billion and a half chicks and poults hatched in the United States are produced at hatcheries cooperating in the breeding-improvement and pullorum-disease-eradication programs of the Poultry Improvement and Turkey Improvement Plans. Breeding-improvement and pullorum-eradication work done by cooperating breeders and flock owners has contributed to the sharply increased egg production and decreased brooding mortality of farm flocks. The percent of pullorum-disease reactors is less than one-third of that of 5 years ago.

THE BELTSVILLE SMALL WHITE TURKEY

In recent years a demand has developed for smaller turkeys to meet the needs of fully 75 percent of retail purchasers and to fit kitchenette ovens. Poultry breeders at the Center have succeeded in producing a small-type turkey, white in color, with a compact body, short legs, a long keel bone, and plenty of breast meat. This Beltsville Small White Turkey is the result of a combination of several varieties, each contributing one or more of the characteristics desired.

The average live market weight of this variety ranges from 12 to 17 pounds for the males and 7 to 10 pounds for the females as compared with average market weights for large-type turkeys of 25 pounds for the males and 15 pounds for the females. The Beltsville Whites are in finished market condition at 22 to 24 weeks of age. The number produced has increased rapidly, and the variety has been found
to be especially well adapted to meet a year-round market for young turkeys 14 to 17 weeks old weighing 4 to 8 pounds dressed.

POULTRY DIETS

Specialists in poultry nutrition at the Research Center have developed more efficient and more economical diets in which soybean meal is the major source of protein. During World War II, animal byproducts, the standard source of protein for poultry feed, became scarce and soybean meal was substituted in increasingly large quantities. Without animal protein, the hatchability and livability of chicks went down as the level of soybean meal in the hen's diet went up. Scientists at the Center found that the trouble could be corrected by feeding the hens small amounts of dried cow manure and concluded that the manure contained a growth substance or unknown vitamin also present in animal products, including milk, meat, liver, and fish. Research men at a commercial laboratory who were also working on the problem isolated a new vitamin, B₃, which proved to be the unknown factor found by the Research Center scientists. It is now produced commercially in quantities sufficient to supplement soybean meal in poultry feeds.

The search begun by scientists at the Center for new commercial sources of vitamin B₃ in turn led to the discovery by a commercial laboratory that aureomycin and other antibiotics produce growth stimulation in young chickens. Recent
research has shown that by adding vitamin B₁₂ and antibiotics to broiler and turkey feed, poultrymen can produce 3-pound broilers on about 3 pounds less feed and in 3 weeks less time than are usually required with a more expensive diet in which all the protein comes from animal sources.

Recent studies at the Center on the effect of light on growth of chickens have shown that chickens grow most rapidly when they eat in 1-hour shifts with 3-hour rest periods between. Chickens that were given 1 hour of light, 3 hours of darkness, 1 hour of light, and so on around the clock made about 40 percent greater growth during the first 18 days after hatching than did chickens given alternating 12-hour periods of light and darkness. Continuous light produced about 25 percent increase in growth over that obtained with 12 hours of light and 12 of darkness. Just enough light to permit the chickens to eat was as efficient as greater intensities of light.

LIVESTOCK DISEASES ATTACKED BY SCIENCE

Research projects in animal diseases usually extend over a period of years, and the importance and practical application of the results may not become apparent for a number of years. Most of the livestock-disease work at the Agricultural Research Center is conducted at the Animal Disease Station, which covers an area of approximately 350 acres, about 100 of which are used for growing feed crops for the experimental animals.

The 200 structures on the station grounds include laboratories, hospital houses, small-animal breeding houses, an incinerator, and various barns and pens. About 400 large experimental animals—horses, cattle, sheep, goats, and swine—and about 1,000 fowls are maintained. Numbers of small animals, such as guinea pigs and mice, are raised to supply the needs of the Animal Disease Station and other laboratories of the Bureau.

Brucellosis (Bang's disease) of cattle has received major attention. It was at this station that the antibrucellosis vaccine (strain 19, *Brucella abortus*), now widely known throughout the world, was first made. The studies have shown that no medicine now known can cure the disease but that vaccination of calves is a preventive.

Brucellosis in swine, anaplasmosis and mastitis of cattle, and sterility of cattle resulting from hormonal imbalance also receive major attention.

Other diseases under study are infectious anemia and sleeping sickness of horses; tuberculosis of cattle, swine, and poultry; paratyphoid and erysipelas infections of swine; vesicular stomatitis of cattle, hogs, and horses; and fowl typhoid and Newcastle disease of poultry.

All diagnostic antigen used in the Federal-State program for the control of brucellosis and strain 19 vaccine are prepared at the Animal Disease Station. All similar commercial products are tested here for purity and potency.

Research on diseases that resemble foot-and-mouth disease and thus may be confused with this foreign malady has provided information that aids in a prompt and correct diagnosis when foot-and-mouth disease is suspected. Four training schools for Bureau veterinarians in the field have been conducted at the station.

STRATEGY AGAINST LIVESTOCK PARASITES

Another section of the Research Center, comprising approximately 110 acres, is devoted to animal-parasite investigations. A part of this area is divided into 54 plots, varying in size from 1/4 acre or smaller to 5 acres, which are used as pastures or for small-scale field experiments. About 500 large animals, including horses, cattle, sheep, goats, and swine, and about 1,200 chickens and turkeys are maintained for
experimental purposes. Facilities include an administration building, 3 laboratories, and 4 other buildings used for research studies. In addition, there are 75 miscellaneous buildings, barns, and shelters for the animals, an incinerator, and other miscellaneous structures.

Here zoologists and parasitologists of the Bureau of Animal Industry study the vast number of parasites that attack livestock and develop treatments and control measures to protect domestic animals and poultry from them. Part of the strategy in waging war on these pests is to determine the most vulnerable points in their life cycles and then find a drug or husbandry practice that will break the cycle. Such research has developed treatments with phenothiazine for removing injurious worms that infest horses, cattle, sheep, swine, and poultry; sodium fluoride for removing roundworms from swine; and lead arsenate for removing tapeworms from sheep.

These and many other discoveries have helped to make livestock and poultry raising safer and more profitable. Sometimes the results of research show how a combination of methods can best be used. For instance, the experimenters found that larvae of the stomach worm, nodular worm, and other injurious internal parasites of sheep did not survive under pasture conditions for more than 4 months. This fact formed the basis of a control program that involved treatment of the breeding flock with phenothiazine late in the fall and early in the spring and then placing the sheep on pasture that has been allowed to lie idle over winter. These facts are useful in formulating control measures for the parasites.

Vaccinating a 7-month-old calf at the Animal Disease Station for protection against brucellosis.
Bureau of Dairy Industry

BUILDING BETTER DAIRY HERDS

Dairy research at the Agricultural Research Center is concerned with numerous problems that affect the efficiency and profitableness of dairy farming. The work includes studies in breeding, feeding, and management to improve the milk-producing ability of dairy animals; determination of their nutritional requirements for normal growth, lactation, and reproduction and the feeds or feeding regimes that will supply the needed nutrients most efficiently; and investigations of the physiological factors affecting the general usefulness of dairy cattle.

The experimental herds used for breeding and nutrition studies now consist of about 500 animals of all ages—representing Holsteins, Jerseys, and crossbreds of various breeds. Land used for pasture and hay crops in connection with dairy operations consists of about 600 acres. In addition, the facilities at the Center include a well-equipped laboratory building for dairy-products research.

A big problem in breeding dairy cows has been how to reduce the percentage of the low milk producers born in practically every herd each year. It has been estimated that only one-third of the country’s dairy cows return a profit, one-third break even, and one-third fail to pay for their keep.

Records of the production of cows in the dairy herd at the Center, kept for over 30 years, have proved the theory advanced by scientists of the Bureau of Dairy Industry that a bull whose daughters are consistently better milk producers than their dams is relatively pure in his genetic makeup for the factors that insure high levels of milk production. Thus, the use of such proved bulls for several generations gradually builds up milk production in the herd.

On the dairy farm the cows that do not pay for their keep are usually culled, but at the Research Center the object is to get information on breeding. Therefore, no females are culled from the herd. All are raised and tested for production. Every effort is made to avoid practices that might interfere with or bias the interpretation of results in terms of inheritance.

A herd of registered Holsteins was established at the Center in 1918 and a herd of Jerseys in 1919 for experimental purposes, particularly to determine the value of using proved sires. To date, 7 proved sires have been used in the Holstein herd and 15 in the Jersey herd. At the present time the females for the eighth and ninth proved-sire generations of Holsteins are being artificially bred to selected proved sires in artificial-breeding associations in New York and Pennsylvania. The average butterfat production of the foundation cows in the Holstein herd was 678 pounds a year, and in the Jersey foundation herd it was 622 pounds. In both herds the number of low-producing daughters has gradually diminished with each succeeding proved-sire cross, and butterfat production per cow now averages about 200 pounds higher than for the highly selected foundation cows—an increase of approximately 30 percent.

Proved sires brought in for service at Beltsville are usually past 7 years of age. This is beyond the prime for the majority of dairy bulls. Daily exercise has always been highly regarded as a conditioner and as a method to prolong the usefulness of bulls. However, few old bulls will voluntarily exercise themselves, so a compulsory exercise program was set up at the Center. An exerciser was designed and built that has forced many a herd sire to walk himself into a useful old age.
Young bulls from the Holstein and Jersey herds are loaned to cooperating dairymen, institution herds, bull associations, and artificial-breeding rings. The purpose is to determine their transmitting ability by comparing the production records of their daughters with those of the dams of the daughters. About 80 percent of these bulls in cooperating herds have sired daughters that have produced more milk and butterfat than their dams. On the average, all daughters of the bulls bred at the Center have exceeded their dams in production by approximately 800 pounds of milk and 38 pounds of butterfat.

In 1939, a cross-breeding experiment was started at the Research Center to develop as much useful information as possible. Proved sires of the Holstein, Jersey, and Red Dane breeds are being crossed with females of these three breeds and also with Guernsey females. The major plan of the experiment differs from the usual pattern of cross-breeding in that it calls for continuous introduction of new genes (units of inheritance) through the use of proved sires of the respective breeds. The females resulting from the mating of two breeds—Holsteins and Jerseys, for example—are mated to a Red Dane sire for the three-breed crosses. The resulting three-breed females in this case are then mated to either a Jersey or Holstein proved sire in a second round of the three breeds involved. The majority of the two-breed females have produced markedly more milk and butterfat than their purebred dams, and the majority of the three-breed females and later generations of crossbreds have more than maintained this high production. One of the striking characteristics shown by all the crossbred heifers is their persistency in milk production. To date the results are as follows: The 55 foundation purebreds averaged 455 pounds of butterfat (actual basis) in the first lactation. Under the same conditions their 55 two-breed offspring averaged 586 pounds, and 57 three-breed females have averaged 589 pounds.

In 1946 an experiment was inaugurated at the Research Center in an endeavor to breed cattle better adapted to the severe climatic conditions that prevail in the Gulf coast area during the summer months. This work is being conducted as a part of the Southern Dairy Cattle Breeding project and in cooperation with several Southern State experiment stations.
Very little is known about the milking qualities of most strains of Brahman cattle, but it is generally believed that they possess greater heat tolerance than our own dairy breeds. The Allahabad Agricultural Institute at Allahabad, India, has developed a herd of Red Sindhi cattle (a Brahman breed) in which considerable attention has been given to selection for milk-producing qualities. Late in 1946 two young males and two young females from this herd were brought to the Center to serve as a nucleus for some of the breeding work to be conducted on this project. Matings of the Sindhi bulls with our own dairy breeds were planned in order to determine milk-producing and heat-tolerance qualities of such crosses.
So far, 45 males and 58 females have resulted from the various matings, and 16 of the crossbred females have completed one or more lactation records. All the crossbred animals are being studied from the standpoint of production, growth rate, and heat tolerance.

A heat chamber has been constructed in which to study the heat tolerance of dairy animals under standard and extreme conditions, and various types of equipment have been developed to determine and evaluate the reactions of the animals to severe heat stress.

THE DAIRY-ANATOMY PUZZLE

How to identify high-producing cows on the basis of appearance and body characteristics has puzzled dairy-cattle breeders for 150 years. Many have thought they have found the answer and have offered what seemed to be convincing evidence. Some still cling to theories of a century ago. From time to time new theories have been advanced. There is little if any scientific basis for most of the theories, yet large sums are spent every year in conducting cattle shows and in teaching the principles of dairy-cattle type and judging to farm boys and girls, college students, and dairy farmers. A dependable knowledge of the significance of dairy form is much to be desired, since at least 95 percent of dairy animals are selected without the aid of production records.

To provide a proper basis for identifying both superior and inferior producing capacity, scientists at the Research Center have been conducting a study that involves the measurement of body form in the heifer and in the cow and the determination, after slaughter, of size of all internal organs and body parts. More than 540 cows with records of production have been slaughtered and measured according to this procedure. In addition, more than 460 cows of known producing capacity have been slaughtered in accordance with the same plan and as a part of the same study at various State experiment stations. The work has already provided data showing how dairy animals grow and how their form changes with age, as well as the average weights and measurements of the anatomical parts of the cow—all as a scientific approach to the yet unsolved puzzle of judging production from conformation.

Special emphasis has been given to a study of the udder. When a cow or heifer is slaughtered at the Center her udder is removed, suspended in a natural position, filled with formalin, frozen, and later cut into vertical slices to show the structure of the glands at various ages and to provide a basis for studying the relation between tissue structure and producing ability. The sectioned udders are photographed. Several hundred specimens of typical and abnormal cases have been preserved and are available for examination by visitors and students.

After several years of research a method has been developed that offers much promise of making it possible to prejudge the potential producing ability of a calf when she is only 4 to 5 months of age. Examination, by palpation of the udder, shows marked differences in the degree of development of the mammary glands in individual calves. It has been found that, in general, those with relatively advanced development make substantially better milk producers than those with retarded development of the mammary glands at the same age. If the results obtained at Beltsville are upheld by field tests now in progress, the judicious selection of herd replacements should be possible during early calfhood, and a preliminary appraisal of a herd sire might be obtained when his daughters are less than 6 months of age. The palpation examination is not difficult and can readily be explained by demonstration.
A dairy management specialist examines the stems of cut alfalfa that have been crushed by the heavy rolls of this modern machine—the mower-crusher—to make the stems dry faster and thus decrease the time required for field-curing the hay.

**DAIRY CATTLE NUTRITION AND MANAGEMENT**

Research in nutrition and dairy-herd management has contributed to the solution of several problems connected with the rearing of calves for herd replacements and the production of milk. It is estimated that calves consume about 1,750,000,000 pounds of whole milk annually. That this quantity may be reduced is evident from research work at the Center, where calves have been reared without the use of any marketable whole milk and have been weaned at various ages from all milk and milk products. Other research has shown that growing calves will eat more hay when they have free access to it all day than when it is fed several times a day. Experiments also show that colostrum milk, which is essential for proper nourishment of newborn calves, can be fed to older calves safely when it is properly diluted with warm water. Colostrum is a highly concentrated feed and provides more nutrients, pound for pound, than whole milk.

The simple, open-shed system of stabling cows has been found to be satisfactory under conditions at the Research Center. Cows housed in this manner produced as much milk, stayed as healthy, and kept as clean as those stabled in the common type of closed barn. This research proved that an expensive barn is not necessary. If cows are kept dry and out of cold winds, the essential conditions of satisfactory housing, from a production standpoint, are largely met.
Pasturage can be the best or the poorest of feeds. Research at the Agricultural Research Center has shown that, when the grass is young and abundant, cows will graze enough to support a production twice that of the average cow; but when the grass is dried up, short, or matured, as is often the case in midsummer, the cows may not graze enough to support the production of more than a few pounds of milk a day. Studies extending over several years are now in progress on methods of renovating and treating pastures, crop rotation with pastures, and pasture management.

The Bureau of Dairy Industry has been conducting research for several seasons to find the best method of saving the nutrients grown on the farm in the form of roughage. Comparing three different methods of harvesting and storing hay crops—field curing, barn finishing, and making wilted grass silage—the investigators showed that, with the same crop, the losses of dry matter, protein, and carotene (provitamin A) were greatest when hay was cured in the field, next when it was dried in the barn without heat, and least when it was made into silage. Experiments have demonstrated that, through proper control of moisture, good silage can be made from any of the hay crops and that it is unnecessary to add molasses, acid, or any other purchased materials. To take the place of pasturage and prevent the summer slump in milk production, no feed excels good grass silage. Work is now in progress to determine the efficiency of airtight, glass-coated steel silos, which unload from the bottom.

A vitamin A deficiency in young dairy calves may cause the development of a cyst in the pituitary gland. Hormones secreted by this gland are essential for reproduction and lactation. Experimental results indicate that, at least in the male, the subsequent feeding of vitamin A does not cure these cysts, but that animals may be fertile even when large cysts are present.

Dairy manufacturing specialists dip the crude protein from Swiss cheese whey, preparatory to converting it into a smooth, bland, semisolid substance that can be used as a base in making various types of food spreads.
A preparation from casein and iodine called thyroprotein has been shown to function like the hormone thyroxine, which is secreted by the thyroid gland, and to increase milk production when fed to cows in the declining phase of the lactation. Experiments have shown that this increase is temporary unless the cow is given enough extra feed to maintain body weight and milk production and that there is no increase in total milk production when thyroprotein is fed over the greater part of the lactation. No bad effects on the health of the cows have been noted when thyroprotein was fed for several successive lactations.

Investigations are being conducted on the nutritive value of milk and methods of improving it, particularly its vitamin A potency. This work long ago showed the presence of an unidentified nutrient in milk, which was called nutrient X. Recent work has identified nutrient X as vitamin B₁₂. This new vitamin has been found in the nonfat portion of milk, cheese, commercial casein, leafy foods and feeds, and liver extracts, but not in cereal grains and oil meals.

Other nutrition experiments have shown the most practical level of protein to feed milking cows; the minimum amount of calcium required by growing calves; and the effect of feeding cows a ration of grain and corn silage. Work is now in progress to determine the vitamin A requirement of calves; the cause of nutritional anemia in calves; the effect of feeding older calves an all-roughage ration, including grass silage; and the content of the insecticide in the milk of cows fed forages that have been sprayed with insecticides.

CHEESE MAKING

Investigations to develop processing procedures that will improve the quality of dairy products and simplify their manufacture are mostly carried out in the Washington laboratories of the Bureau. Cheese, however, is made at the Research Center in a building especially equipped for the purpose. All the steps in making cheese, from the curdling of the milk through the cooking, milling, and pressing of the curd, and the curing of the cheese, are carried out with equipment of the commercial type. Swiss, American Cheddar, and Cottage cheese are being studied at present. Efforts are being made to convert the protein of cheese whey, a byproduct often fed to animals or wasted, into suitable forms for use as human food.
The function of this Bureau is to protect man, animals, and plants from the attacks of harmful insects and to increase the usefulness of beneficial insects. Various laboratories and offices of the Bureau at the Agricultural Research Center study problems in these fields, both by actual research and by supervising the activities of a great number of entomology research laboratories located throughout the United States. Only a very small part of Federal research in entomology is conducted at the Center.

STUDYING INSECT PROBLEMS

One of the first steps in studying insect problems is to detect the presence of insects and to estimate the results of their attacks. The Division of Forest Insect Investigations, which is responsible for research on forest, shade tree, and wood products insects, has one of its 11 field stations, as well as its headquarters, at the Center. A major project of the Division concerns aerial surveys of insect damage to forested areas and the development of apparatus and techniques for making such surveys, as well as for spraying extensive forested areas by means of planes. Several airplanes are based at the Research Center airfield for studies of this kind.

Research on aerial surveys includes the development of devices for recording the extent and intensity of insect damage observed from the air and the use of colored photographic techniques for detecting individual trees or groups of trees defoliated or having off-color foliage as a result of insect attack. These methods make it possible to survey, at low cost, enormous acreages of otherwise inaccessible forest areas.

Studies of equipment for and methods of aerial spraying, along with studies of aerial survey, have been of great value in controlling spruce budworm in Oregon and Washington and in surveying the spruce-fir forests of Maine for the presence of heavy infestations of this insect.

To aid in research of insect problems, thousands of test insects such as mosquitoes, flies, and cockroaches are reared under rigidly controlled conditions at the Research Center by the Division of Stored Product Insect Investigations. There is continual research for better techniques to produce more nearly “standard” insects for testing. Special strains are perpetuated and exchanged so that all testing work, either at the Center or elsewhere in both governmental and commercial laboratories, may be compared with reasonable assurance that the results are accurate and dependable.

New botanical and synthetic materials are screened for insecticidal effect. Results of these laboratory studies form a basis for subsequent field tests by other Bureau workers.

Insects that survive exposure to insecticides begin to develop resistance to those insecticides. Resistance may develop more or less rapidly after repeated exposure to the modern residual-type materials such as DDT, lindane, and chlordane. Physiologists and biochemists of this Division are studying the physiology of resistance in order to learn how it develops, what steps may prove effective in preventing its development, and how such resistance may be overcome.
Bee culture, insect pollination, and bee-disease control are studied by the Division of Bee Culture and Biological Control. A diagnostic service is maintained for beekeepers and bee inspectors for such diseases as American and European foulbrood, nosema disease, sacbrood, and other bee ailments. Because of the serious losses caused by American foulbrood, early and accurate diagnosis is essential to eradication of the disease.

Thousands of requests for information on beekeeping are received from beekeepers in the United States and in foreign lands. The Center has the world’s largest beekeeping bibliography, as well as an extensive beekeeping library consisting of hundreds of books and periodicals in various languages.

This Division collects, imports, and distributes natural enemies of insect pests and weeds; exchanges beneficial insects with other countries; studies the effect of insect-control methods on beneficial insects; and studies insect diseases and their use in the control of insect pests.

**CONTROLLING THE INSECT**

Much of the entomological research at the Center has to do with insecticides and methods of applying them. The Division of Insecticide Investigations conducts research to find new and more effective insecticidal materials. New organic compounds made by chemists are tested by entomologists and then more thoroughly investigated in the field and orchard.

Chemicals produced by plants are also tested for insecticidal value. Within recent years, the structure of pyrethrins, the active principles of pyrethrum flowers, has been worked out, and a compound similar to one of the major components, called allethrin, has been synthesized. Allethrin is now in commercial production.

Some of the new “systemic” compounds tested by the Division of Truck Crop and Garden Insect Investigations, either as sprays applied to plants or incorporated in the soil, give phenomenal control of aphids and spider mites through translocation of the chemicals within the plants. One treatment with small quantities per unit of greenhouse space may give excellent control over periods of several weeks. These systemic insecticides are used so far only for flowers and other ornamental plants.

The Bureau of Entomology and Plant Quarantine maintains several airplanes at the Research Center airport for use in research in aerial spraying methods and equipment.
Wearing a gas mask, a research worker sprays greenhouse plants with an aerosol that has proved effective in controlling pests in greenhouses.

They will not be used on food crops until more is known about possible health hazards involved.

Just as some insects have natural resistance to certain insecticides, some plants have natural resistance to insects and to the diseases they carry. Some of these diseases live and multiply on several different host plants, causing serious damage to some strains and only minor damage to others. Information gained from studies of the effects of planting various crops in close proximity on the incidence of such insect-carried diseases has been of great value.

Besides creating new insecticides, the Research Center laboratories develop and improve methods for applying insecticides. The insecticidal aerosol bomb was first developed by Bureau scientists at the Center. It came into prominence during World War II as an aid in control of insect-borne diseases. Under the United States Department of Agriculture patent on this method of dispensing insecticides, Research Center laboratories test all aerosol formulations containing insecticides sold to the public to determine both insecticidal effectiveness and safety in use.

The physical and chemical properties of materials to be used in aerosols are also investigated at the Center. Safe and inexpensive chemical solvents and propellants, types of valves, and deterioration in storage, both of chemical materials and containers, are studied.

The work on aerosols is proving of great commercial value in the control of insects attacking such flowers as roses, chrysanthemums, and carnations, as well as such vegetable crops as tomatoes and cucumbers. The newer organic phosphorus insecticides give almost perfect control of mites, aphids, thrips, and other greenhouse pests.

A highly important phase of the aerosol studies concerns the control of disease-carrying flies, mosquitoes, and other insects. Studies in cooperation with the Department of Defense have produced insecticide formulations and disseminating equipment that are now in military and civilian use.
Increased travel by airplane has greatly increased possibility of the accidental spread of harmful insects in this manner. A method for automatic dispersion of high-pressure aerosols in airplanes while in flight has been developed that insures proper dosage without annoyance to passengers.

Residual insecticides, which have effectiveness for some length of time, are used in aircraft in such places as baggage and mail compartments.

Physical factors in dispersing insecticides are investigated in both laboratory and field experiments. Large-scale equipment, such as mist blowers and fog aerosol machines, is used for dispensing insecticides in large indoor areas such as warehouses and for rapid clearance of insects from extensive outdoor areas.

Particle size and other physical properties of insecticide powders are studied in relation to their effect on dustability, freedom of flow, dispersal by wind currents, and effectiveness as insecticides. Data of this nature are of great service to industry and to entomologists in determining types of dusts, particle size, and other physical factors necessary to produce effective dusting mixtures of various insecticidal chemicals.

Methods of analyzing and determining residues of DDT, benzene hexachloride (BHC), and other materials in foods have been worked out. These methods are used by public health agencies to determine when foods on the market contain excessive amounts of insecticide.

DECREASING INSECT CONTAMINATION

Heavy losses have been suffered by both processors and growers because of insect contamination in processed fruits and vegetables. Research to develop effective dips
and washes for the removal of insects and insect debris from such crops is being
conducted by the Division of Truck Crop and Garden Insect Investigations.

This Division is also conducting studies in cooperation with the Bureau of Plant
Industry, Soils, and Agricultural Engineering to determine the insects responsible
for transmitting virus diseases to chrysanthemum, gladiolus, carnation, and other
greenhouse crops.

Small mushroom houses, operated as nearly as possible under commercial condi-
tions, aid research on mushroom insects. Methods of using the natural "heating"
process of the manure to "pasteurize" it have proved effective in controlling infesta-
tions of mushroom flies, mites, and springtails. Since this heating is an essential step
in preparing the bed, it is a very cheap method of reducing costs of chemical control.
Fumigants, aerosols, insecticidal dusts, sprays, and drenches applied at varying times
during the growing of the crop are also effective in controlling mushroom insects,
and the residual spraying of walls and sideboards is proving valuable.

The effect of certain insecticides upon the production and quality of peanuts,
including the development of off-flavors caused by some of them, is studied by the
Division of Cereal and Forage Insect Investigations.

Research by this Division also concerns control of insects attacking alfalfa and
various clovers. Toxicological studies in cooperation with the Bureau's Division of
Insecticide Investigations and with the Bureau of Dairy Industry are being con-
ducted to determine the possible residue hazard that may be caused by the use of
insecticides on forage and other crops.
Bureau of Human Nutrition and Home Economics

SERVES HOMES AND FAMILIES

The chief governmental agency designated by Congress to study food, fabric, and other goods and services from the standpoint of the ultimate consumer is the Bureau of Human Nutrition and Home Economics. From the laboratories and offices of the Bureau's scientists and professional workers come facts to help the 43 million homemakers of the Nation and members of their families achieve better living in more satisfying homes. The Bureau's work is organized into four research divisions—Food and Nutrition, Textiles and Clothing, Housing and Household Equipment, and Family Economics. All but the last are located at the Agricultural Research Center.

SOLVES CANNING AND FREEZING PROBLEMS

Twenty-one million or more families in this country annually preserve some of their own food. To help them do this work in practical ways, with methods that will prevent spoilage and retain the most food value and flavor, is the aim of food specialists, bacteriologists, chemists, and physicists in the food, nutrition, and equipment laboratories.

Research to develop improved processing methods for canning includes studies to learn the effect of preparation and packing on the eating quality and retention of essential nutrients in home-canned foods. Three years of intensive research yielded new and improved directions for canning meat and 12 of the most frequently canned low-acid vegetables. As a result, the Bureau's how-to-do-it home-canning bulletins now give processing times 25 to 50 percent shorter than previously for vegetables canned in pint-size jars and for some in quart jars and list processing times similar to those in commercial use for foods canned in tin. Processing temperature and amount of pressure to use for home-canned meats are lower than those previously recommended. Using a steam-pressure canner—the only safe method for processing low-acid foods—and following the new schedules, homemakers may now turn out products combining safety with better flavor, appearance, and food value than before. In addition, the new methods save both time and fuel.

The increasing number of home freezers in the Nation—nearly 3 million were estimated to be in use in 1951—and the relative newness of this field of home food preservation put new emphasis on food-freezing research. In the food-freezing laboratories, scientists experimentally prepare, package, freeze, and hold in frozen storage various foods to develop better freezing methods. Heating vegetables before packing has been found necessary to destroy enzymes that reduce the nutritive value, color, and flavor of the products. The amount of heating necessary has been determined by recording temperature changes in the food and testing enzyme activity for different heating times in steam or boiling water. Speedy cooling has been found important for quality.

The color and flavor of fruits that darken readily, such as peaches and nectarines, have been successfully retained through frozen storage and thawing by the use of ascorbic acid and by providing sufficient sirup to cover the fruit.
Home economists use assembly-line techniques for packing jars of food in research on home canning.

Studies comparing home-canned and home-frozen snap beans showed the frozen beans considerably better in eating quality and nutritive value than the canned. Storage for 10 months had little effect on palatability or on the thiamine content of either frozen or canned beans. However, ascorbic acid (vitamin C) retention in frozen snap beans stored for 10 months at 0° F. was considerably higher than in canned samples stored at 70° F.

Based on its freezing experiments, the Bureau has put into an illustrated, how-to-do-it booklet directions for home-freezing more than 80 fruits, vegetables, and fruit and vegetable products.

**DEVISES COOKERY FOR OLD AND NEW FOODS**

In the laboratory kitchens at the Research Center, cooking methods and recipes are developed for home and institutional use. At times the staff has experimented with cookery of new foods, such as soy flour and grits and turkey parts—halves, quarters, and disjointed pieces or "cut-ups." Research is also done to find new ways and more ways of preparing familiar foods. For example, short cuts for the homemaker in cooking dried beans and peas have been developed; also ways for the family to use the cheaper kinds of chicken, such as small, mature hens. Potato varieties grown in different localities and stored in different ways are being compared to learn which potatoes are best for boiling, mashing, baking, and french frying. All recipes from the Bureau’s food laboratories are judged for palatability.

In one of the experimental kitchens equipped for large-scale cookery, recipes featuring widely available foods are developed for the use of restaurants, industrial cafeterias, hospitals, and other institutions. These recipes get an added test for practicability, sales appeal, and consumer acceptance in commercial and other types of food service.

**CONTRIBUTES TO SCHOOL-LUNCH PROGRAMS**

In another kitchen, recipes utilizing abundant foods are developed for use in school lunchrooms. The school-lunch research of the Bureau is supported in part
by the Production and Marketing Administration—the Department's agency in charge of the National School Lunch Program. School-lunch recipes are further tested in cooperating schools, where they are prepared by the school-lunch cook and served to the pupils. A Bureau representative is present to watch the children's choices, hear their comments, and note whether food is left on the plates.

Besides experimenting with cookery, the Bureau is seeking to learn how well school lunches actually served are meeting children's nutritional needs. Sample lunches from cooperating schools are analyzed in the laboratory to determine the content of important nutrients. Based on studies of school-lunch management in 39 schools in different parts of the country, the Bureau has prepared a checklist to help supervisors evaluate and improve such management practices. In 1951 two new slide sets on quantity food preparation were made for use in training courses for school-lunch cooks and managers.

**DETERMINES FOOD VALUES AND NEEDS**

Protein—required by the body for tissue building and repair—is one of the nutrients in which world food supplies are short. Best known sources of high-quality protein are animal foods, such as meat, milk, egg, and cheese. Plant proteins vary widely in value, depending on how many of the 10 essential amino acids, and how much of each one, they contain.

A slow, basic task of protein chemistry is analyzing these foods for amino acids, one by one. In the Bureau's protein research laboratories a number of short-cut microbiological procedures are used to determine certain nutrients in raw and cooked foods.
methods have been developed that are speeding this work here and elsewhere. One method reduces from weeks to days the time it takes to determine several amino acids in food. That the short cuts meet a need is shown by the many requests for the published results coming from hospitals, colleges, and other research and teaching institutions in all parts of the world.

The plant protein studies have shown that the following come closest to animal proteins in nutritive value: Soybeans, peanuts, cottonseed, wheat germ, and corn germ. These have proved efficient enough in tests on animals to be counted on to stretch or spare the proteins of meat and other animal foods when these proteins are scarce, or to be an inexpensive source of protein in the diet of low-income families at any time.

What one protein lacks, another may supply. Sometimes protein in a combination of foods proves more nourishing than that in any one food alone. For example, in feeding experiments with young rats, protein research specialists found that adding 15 parts of soybean flour to 85 parts of wheat flour in bread increased the growth-promoting value of wheat flour fivefold.

Because heat affects the nutritive value of proteins, these scientists are now searching to learn exactly what happens to nutrients when animal and vegetable foods are cooked or canned, and to what extent nutritive values are altered.

Throughout the world a large proportion of the needed vitamin A is furnished by plant foods in the form of carotenes, which the body can transform into vitamin A. Many of the factors affecting the utilization of carotene are not well understood. For example, work in the Bureau’s laboratories showed that the carotene in cooked
kale is utilized better by the body than the carotene in cooked carrots. Even so, the vitamin A value of cooked kale, as determined by feeding experiments, appeared to be only about two-thirds as great as would be expected from a chemical determination of its carotene content. However, when an extract of the carotinoid pigments from kale, rather than the kale itself, was fed as the source of carotene, the feeding value agreed with the chemical value. This indicates that in kale, at least, the difference between the chemical and biological values may be due to incomplete digestion of the vegetable and consequent incomplete absorption of carotene from the intestinal tract. Experiments of a similar nature have shown that the carotenones of cooked sweetpotatoes and canned pumpkin are less well-utilized than those from kale and that the carotene from yellow corn meal is better utilized.

Food composition tables compiled from scientific literature present nutritive values for about 750 items of food. These tables, recently issued, are in great demand by scientists, dietitians, and physicians for developing and appraising the nutritive content of diets of individuals or of families.

WORKS OUT FOOD BUDGETS

Because food comes first among money expenditures for family living, the Bureau, since 1930, has developed food plans to help families improve their diets and get better returns in nutritive value for money and labor expended. These plans are based on the latest scientific findings, current food supplies, and price relationships. They recognize customary family food habits, are developed at different cost levels, and provide acceptable menus as well as adequate nutrition.

Guidance material for teachers and social welfare workers has been prepared, such as the bulletin entitled, "Helping Families Plan Food Budgets." The most recent food budget aid is called "Food Guide for Older Folks," which recognized the food problems of the increasingly large group of older people in this country.

DISCOVERS FACTS ABOUT FABRICS

The research on clothing and fabrics from the consumer standpoint aims to show producers what people need and want in staple garments and fabrics and ways in which materials on the market can be improved to meet needs. The Bureau also seeks to provide facts that will help homemakers choose, use, and care for the clothing and textile products they buy.

Some kinds of scientific textile testing have to be done where the weather never changes. For these, an air-conditioned laboratory is equipped with machines to measure fabrics for strength, stretch, and resistance to abrasion. Other laboratories have equipment to do a scientific laundering job and to measure how much fabrics shrink on washing. An artificial sun can be turned on fabrics to show how fast or fugitive the colors are.

Better care of textiles in the home calls for more knowledge about what makes fabrics deteriorate. Accordingly, other fabric studies are concerned with deterioration in cotton and, more recently, in wool and other fibrous protein materials. In comparing the effect of certain enzymes on wool and other protein fibers, the textile scientists found that deterioration varied. One currently available manufactured fiber made from corn protein had about the same resistance to the enzymes as wool; its impairment was only about 2 percent.

Another phase of microbiological research with textiles is that concerned with the sanitation of clothing. Increased use of new household laundering disinfectants,
especially for infants' clothing and bedding, prompted study of five compounds sold under various trade names for this purpose. Results showed that directions recommended by the manufacturers generally did not provide strong enough treatment to disinfect the fabrics. In further work, amounts of disinfectants needed to sanitize and disinfect clothing were determined.

In other research, the Bureau studied the relative serviceability of different constructions of percale for housework dresses. These fabrics, made under identical conditions from cotton of known origin, were made into dresses and worn by students in food-preparation classes in home economics departments of cooperating institutions. Accurate records were kept of the amount of wear and the number of launderings given each garment. It was found that high-count percales (about 80 yarns per inch in each direction) wore about twice as long as fabrics having 60 yarns in the warp and 48 in the filling.

PROVIDES GUIDES FOR CLOTHING SELECTION

One way in which some of these lines of research reach the public is in buying-guide publications, designed to help the homemaker shop for household fabrics and clothing. Cotton and wool fabrics, sheets, blankets, bath towels, window curtains, women's cotton housework dresses, slips, hosiery, and men's and boys' shirts and suits at one time or another have been studied and the results discussed in the series of publications issued. The most recent bulletin is entitled, "Buying Sweaters for the Family." Manufacturers also use these research findings to produce more acceptable articles for consumers.

This machine, designed in the Bureau of Human Nutrition and Home Economics for measuring the elastic properties of knitted fabrics, was recently patented in the public interest.
The Bureau pioneered in designing clothes for women and children that provide comfort, protection, efficiency, durability, and, in some cases, safety. A group of protective outdoor garments, recently designed, brought to 38 the number of functional clothes designs for women that have been released for public use.

**DESIGNS FUNCTIONAL HOUSE PLANS**

In the housing laboratories, research moves forward on some of the points important to a good farmhouse. For example, how much space is needed in the farm kitchen to store food and utensils properly to allow room to do jobs comfortably and well? A step-saving U-shaped kitchen designed in the laboratories puts some of these findings on space needs to use. A recent publication sets forth the principles to be used in planning the kitchen and workroom and illustrates efficient layouts of space and equipment. It also includes information on installed equipment, tabletop and floor materials, and wall finishes.

The Bureau's specialists are joining forces with architects of the Bureau of Plant Industry, Soils, and Agricultural Engineering in developing new farmhouse plans for distribution through the Plan Exchange Service, which the Department of Agriculture conducts cooperatively with the State agricultural colleges. From farmhouse plans prepared at the Research Center and at the colleges, regional committees select those which most nearly meet regional needs. State colleges then make the working drawings and plans available to farmers.

A step-saving kitchen, in which storage spaces, lighting, and work centers were designed on the basis of research findings, is on view at the Research Center.
These two bureaus have also cooperated in designing a walk-in refrigerator that provides two temperatures—zero in the frozen food compartment and 35° to 40° F. in the chill room. The design takes into account adequate storage space in the refrigerator, type and cost of installation, problems in construction, cost of operation, operating problems, and the family's habits of use.

Also prepared jointly by these two research units are recommendations for lighting the home, yard, and farm buildings properly to protect eyesight, make work easier and safer, and contribute to the productivity of the farm. Selection, care, and upkeep of common types of fixtures and lamps are included in the recommendations.

ANALYZES HOUSEHOLD EQUIPMENT

When food is well prepared and packaged for freezing, the freezer and storage cabinet take over responsibility for a good product. Hence, one research group at the Bureau has investigated home freezers—their ability to freeze food and hold it at temperatures best for retaining quality. A freezer should be capable of continuing this service year after year at economical operating cost. A method of testing the performance of home freezers has accordingly been worked out. Estimates of freezer capacity needed by farm families have varied from 5 to 15 cubic feet per person. The Bureau has formulated tables to enable families to find as readily and simply as possible the freezer size that applies to their own needs.

Teams of experts and helpers are also investigating what different types of household laundry equipment can do. From what they discover come recommendations as to kinds, sizes, and designs that meet modern homemaking needs. As each kind of equipment is studied, suggestions on selection and care are prepared for homemakers' use. These studies also furnish facts needed for setting up standards to assure that the equipment will operate satisfactorily in the home.
Plant breeders of the Bureau of Plant Industry, Soils, and Agricultural Engineering seek new varieties of fruits, vegetables, grains, grasses, fiber plants, oil plants, drug plants, and nuts that will meet the world’s changing needs. One important requirement of a new variety is resistance to the diseases that from time to time threaten to destroy a whole industry. Other requirements are better eating quality, high yield, and good keeping and shipping qualities. Adaptation to some specific purpose, such as method of harvesting or type of processing—whether canning or freezing—is often desirable.

Modern plant breeders are not satisfied with selecting good types, getting them to breed true, and using them to replace the old ones. Rather, they formulate an ideal in their minds and proceed to create something that meets this ideal as nearly as possible by combining the genes—units of inheritance—from two or more plants. Their ambition does not stop at getting a plant with a single desirable characteristic. They strive for many wanted characteristics in one plant—for example, high yield, high quality, and resistance to many diseases.

**BETTER VEGETABLES, FRUITS, AND FLOWERS**

Probably a third of the fruit and vegetable research at the Plant Industry Station has to do with breeding better varieties and strains. The other two-thirds is largely directed toward studies of crop quality, growth, and nutrition, together with investigations of the causes and control of fungus, bacterial, and virus diseases of fruits and vegetables.

Ornamental plants also receive active attention by plant breeders at the Station. Among other things, the breeders have provided new varieties and methods for the domestic bulb industry that have helped replace Japanese Easter lily bulbs with superior domestically grown lilies. Snapdragons, azaleas, carnations, and daffodils are also being improved through breeding research.

New lima bean varieties of good eating and market quality and dependable yields have been produced in several sizes adapted for different purposes and for wide areas. One of these, Fordhook 242, introduced in 1943, has become the most important large-podded variety for shipping, for market gardeners, and for home gardens. Commercially acceptable types that are widely adapted and resistant to nematodes, insects, and diseases are objectives of the program, which has become country-wide in its scope through cooperation with State workers interested in lima beans.

A new heat-resistant, slow-bolting leaf lettuce, named Slobolt, developed at the Station, has made lettuce growing for home use possible in areas where temperatures are too high for success with the old standard varieties. Slobolt has made it possible to have lettuce in the home garden throughout the summer in many parts of the country. A new early variety of head lettuce, called Progress, was released by the
Bureau and the New Jersey Agricultural Experiment Station in August 1948. An attractive new leaf lettuce, called Salad Bowl because of its unique appearance, was released in 1952.

A potato-breeding project of wide scope centers in the laboratories and greenhouses at the Plant Industry Station and extends to various cooperating States. The cooperative National Potato Breeding Program of the Agriculture Department and the States has brought out many new varieties that already stand high in the esteem of farmers and consumers. Careful breeding work is creating varieties of potatoes with resistance to the important diseases combined with other good qualities, such as right time of maturity, good shape, adaptation to a locality, shallow eyes, high yield, and good cooking characteristics.

Breeding work with onions has resulted in the hybrid onion industry. More than a dozen onion hybrids are now available to growers.

The fruit-breeding work of the Bureau of Plant Industry, Soils, and Agricultural Engineering and cooperating State stations is particularly important to growers of peaches, grapes, pears, strawberries, blueberries, and cranberries.

Strawberry breeders have grown more than 500,000 different seedlings from which a few thousand were selected for further testing. Only 26 have been finally considered worth naming and introducing to the trade, though several others are still under test. Some are now widely grown commercially, to the great satisfaction of growers, shippers, freezers, and consumers. One, the Blakemore, is the most extensively grown variety in the United States today. Strawberries in the eastern United States are almost completely infested with hidden virus diseases. Special testing techniques have permitted the isolation of clean stocks of 25 varieties that are now being propagated for release.

Tomato-breeding work in the United States Department of Agriculture began approximately 35 years ago. Even earlier than that there had been some work in

To prevent the fruits from falling off potato plants painstakingly grown for breeding purposes, the potato specialist puts them into a bag.
leading tomato-growing States, directed especially to developing resistance to fusarium wilt. Since then, practically all of the old varieties have been replaced in commercial fields by new ones, and as a result the industry is on a sounder basis than formerly. Paralleling this improvement, there has been an enormous increase in tomato acreage. The concentration of the industry has made the disease problem greater and the need for new varieties more acute.

Great impetus was given to improvement in disease resistance in tomatoes through the Agriculture Department’s introduction of the Peruvian wild currant tomato about 1930. This variety proved highly resistant to fusarium wilt and several other diseases of tomatoes. It has been used by many breeders in developing new varieties, including some that are resistant to cladosporium leaf spot, a disease of much importance now in commercial greenhouses and in some fields where high humidity and cool temperatures are prevalent during the growing season.

FIELD CROP DEVELOPMENT

The breeding of disease-resistant varieties and investigations of other disease-control methods are the chief activities in the improvement of cereal, forage, tobacco, and sugar crops at the Plant Industry Station. Collections of varieties of barley, wheat, oats, alfalfa, clovers, soybeans, and grasses from all over the world are maintained at the Station.

The greenhouse facilities make it possible in some cases to grow an extra crop during the winter months, thus speeding the development of new varieties. Seed produced during the winter may be sent to another locality for planting in the spring and this in turn may produce seed for a third crop, all in the same year. In this way, seed of promising varieties may be built up rapidly for field testing at many locations for further selection.

The history of crop breeding for resistance to disease illustrates a fundamental point in such work; namely, that so far as can be seen the improvement of crop varieties must be a continuous process. On one side is nature’s creation of new diseases and races of diseases. On the other is man’s constant search for genetic resistance and the development of varieties that will stand up under the attacks of diseases organisms. In order to find needed resistance characters, it is sometimes necessary to conduct inoculation or other screening tests on thousands of varieties from all parts of the world. The search for resistance to race 15 B of wheat stem rust is an example. Much of this work is done at the Plant Industry Station not only on cereals but also on other field crops. Once the desired plant characteristics are found, the long process of crossing and back-crossing to transfer these characters into good commercial varieties begins.

Back of almost every plant breeding achievement in field crops, there is a story of painstaking work of this kind. Hybrid corn, for example, was developed only after years of effort by many scientists. It has now been rather generally adopted by farmers in the United States. In 1951, 81 percent of the total corn acreage was planted to hybrids. In the central Corn Belt States hybrid corn occupied almost 100 percent of the acreage.

Plant breeders are constantly striving for crop varieties having high and dependable yielding capacity as well as high quality. Testing of wheat varieties for high milling and baking quality, barley varieties for malting quality, and feed crops for nutritive value are a part of the crop-improvement process. In cotton, for example, spinning quality is one of the important desired characteristics. Scientists at the Station carry on studies to determine fiber strength and spinning quality. On the basis of these tests, they can predict the yarn strength of different varieties.

In addition to the greenhouse breeding and developmental work, further testing and selection are carried on in nurseries and field plots at the Station. These investi-
gations include such problems as grazing management of grasses and clovers. Extensive research is also under way at the Station on chemical materials for weed control in field crops.

**COLD-STORAGE EXPERIMENTATION**

At the Plant Industry Station is a modern, fully equipped, experimental cold-storage plant, with 16 rooms in which temperature and humidity can be controlled. Here are studied the effects of growing practices and time of picking on storage quality of apples and other fruits; the influence of different methods of packaging and treatment on storage quality and loss from decay in fruits and vegetables; and the effects of carbon dioxide and of small quantities of ozone in the storage air on quality of fruits and vegetables and loss from spoilage.

Cold-storage investigations have brought many results of value. For example, it has been found that the eating and canning qualities of the Kiefer pear—grown largely in the Southeastern States—can be greatly improved by keeping the fruit at certain temperatures. Another example is the great saving in transportation costs—as much as a million dollars a year—that has been brought about through the adaptation of findings of research on the icing of vegetable and fruit refrigerator cars.

**CHEMICALS AND LIGHTS REGULATE PLANT GROWTH**

Hundreds of chemicals are being investigated to detect any new compounds that might control weeds or regulate the growth, development, fruiting, or keeping quality of useful plants. New materials are first applied in small doses, and those that appear to be effective are subjected to extensive testing to determine their possible practical value. Plant growth regulators now are used commercially to prevent the dropping of fruits, flowers, and leaves; to stimulate root growth on cuttings; and to check the sprouting of potatoes. Certain chemicals show promise of serving some of these purposes better than do those now in use. Other chemicals seem to stimulate plant growth or to modify the form of the plant such as by shortening the stem growth.

The effect of length of day on the growth and flowering of various field and horticultural crops is being investigated in greenhouses and special chambers equipped to provide light or darkness at will. These studies include tests of different wave lengths or colors of the visible spectrum. The daily light period, or "photoperiod," determines the time of flowering and adaptation of crops, crop varieties, and strains of native plants to a marked degree.

**DRUG GARDEN AND FUNGUS COLLECTIONS**

More than 200 species and varieties of drug and savory herb plants are maintained in a cultivated garden at the Plant Industry Station. The plants are labeled with their scientific and common names. The garden is at its prime in summer and early fall.

Half a million specimens of fungi are kept in the herbarium of the Division of Mycology and Disease Survey in the North Building, Plant Industry Station, the second largest collection in the United States. One unit is kept at the Station under a cooperative agreement with the Smithsonian Institution, and others belong to the
A soil scientist weighs radioactive phosphate, which will be compounded into a fertilizer for tracer tests. He works in a special laboratory equipped with lead shields, long-handled tools, and other safety devices.

Divisions of Forest Pathology and Sugar Plant Investigations. More than 25,000 species of fungi are included, with about 7,500 species represented by type material or the equivalent. Particular attention is given to fungi that cause plant diseases. Fungus determinations are made, and mycological information is furnished.

In the same building is a collection of living cultures of fungi that cause extensive decay of living forest trees and structural timber. This collection, the largest of its kind in the world, serves as a basis for durability studies on woods essential to airplane, boat, and building construction as well as for diagnosis of tree diseases.

SOIL SURVEYS

The Soil Survey Division has, in the North Building, a large and constantly increasing collection of samples of soils from all parts of the world. The Cartographic Section, which prepares the Soil Survey maps, is located in this building.

RESEARCH WITH RADIOACTIVE CHEMICALS

The Atomic Energy Commission has provided special greenhouse and laboratory facilities at the Plant Industry Station for plant and soil research using radioactive chemicals. This includes constant-environment growth rooms; so-called "hot" laboratories designed for handling radioactive isotopes; and improved facilities for the manufacture of radioactive materials and soil amendments.
Extensive new research is being done on the movement, fixation, and release of phosphorus, calcium, zinc, copper, and sulfur in various soil types by use of radioactive techniques. These investigations will provide new and more precise knowledge on how and when to fertilize different crops on different soils. Procedures for safe and effective use of radioactive isotopes in soil and crop research are being devised. The facilities will also make possible the manufacture of fertilizers incorporating radioactive trace elements for use by other agricultural research agencies and a training program for scientists in the use of isotopes in soil and crop research.

The laboratories where radioactive studies are under way are not open to visitors because of the hazards from radioactive materials.

AGRICULTURAL ENGINEERING STUDIES

Headquarters for the Bureau's agricultural engineering investigations are located on the main tract of the Research Center. Here the engineering divisions conduct research on farm buildings and rural housing, farm electrification, farm machinery, and mechanical processing of farm products.

An engineer determines the presence of blood spots in eggs by means of this electronic equipment
Agricultural engineers and forage, dairy, and marketing specialists are cooperating to study the relative efficiency and merit of various methods of harvesting and preserving forage. During the past several years, emphasis has been on determining the losses in dry matter, protein, and carotene, the palatability, and the resulting milk yield per acre of various methods of harvesting.

In trials with alfalfa, dehydration gave the highest return in milk yields. Barn drying with supplemental heat rated second. These were followed by wilted silage, barn curing without heat, and field curing. Field curing even under favorable weather conditions is the least efficient of the five methods tested.

At the present time, emphasis is on the making of good quality silage and preservation of its nutrients in storage. Included are studies to determine optimum temperatures and pressures necessary to the silage process, the chemical changes that occur, and the effect of various micro-organisms on the resulting product.

ULTRAVIOLET RADIATION ON POULTRY

In studies conducted in cooperation with the Poultry Section of the Bureau of Animal Industry to determine the effects of ultraviolet radiation on egg production, laying hens are irradiated with various wave lengths of invisible ultraviolet radiation that are produced by fluorescent-type lamps varying in size from 20 to 40 watts. Radiation received by the hen varies from very small amounts up to amounts high enough to cause severe eye irritation, and for time intervals of a few hours per day up to continuous 24 hours. This work has been done under conditions where all daylight was excluded, as well as in conventional laying houses. Indications are that a significant increase in egg production results from this practice.

DEVELOPMENT OF AUTOMATIC EGG CANDLING

Work is being done in cooperation with the poultry specialists of the Bureau of Animal Industry to develop automatic equipment for grading eggs on the basis of interior quality. Basic measurements of the light-transmitting and reflecting properties of the egg and its components are being made to determine which of the quality factors can be measured with light energy. The possibility of using other forms of energy, such as ultrasonic energy, as a measuring tool is also being investigated. This work has shown that shell color, egg size, egg shape, soundness of shell, presence of blood, and presence of fluorescing bacteria (which cause “green-rot” eggs) can be determined on an automatic basis.

HIGHER THAN SOUND

Practical agricultural applications of ultrasonics and some of the problems of using high-frequency sound radiations produced electrically are under study by agricultural engineers at the Center.

Limited tests have been conducted in cooperation with plant scientists to determine the effect on germination, growth, and yield of corn when the seed is treated with ultrasonic energy. These tests indicate that treatment with certain levels of energy gives a slight increase in total yield.
The fertilizer distribution machinery laboratory at the Research Center is one of many projects in the United States where agricultural engineers of the Bureau of Plant Industry, Soils, and Agricultural Engineering are doing developmental work on farm machinery. The other projects are located in major crop-producing areas. All research in the actual use of the machines is done at the Bureau's field stations and in cooperation with other Agricultural Research Administration bureaus, State experiment stations, machinery manufacturers, and growers.

The engineers have studies in progress on preparation of seedbeds, placement of fertilizers, application of insecticides and fungicides, and planting, cultivating, harvesting, and handling of crops. The object is to enable farmers to get maximum yields of high-quality products at minimum labor and cost. Industry makes use of the results obtained and of new principles discovered to design machines that help farmers gain these objectives.
Fish and Wildlife Service of the Department of Interior

Closely related to agriculture is the work of the Patuxent Research Refuge, one of the Nation's larger stations for conducting investigations on wildlife problems. This station, located immediately east of the Agricultural Research Center, is administered by the Fish and Wildlife Service of the United States Department of Interior. Within its 2,670 acres are laboratories, lakes, forests, and farms, all devoted to investigations on management of wildlife.

FARMING AND WILDLIFE

A major subject of investigation at the Refuge is that of land use in relation to wildlife production. The effects of modern farm practices on wildlife populations are given close study, and better methods of coordinating wildlife management and farming are tested. Two experimental farms are being developed along contrasting lines: One by the traditional clean-fence-row method, the other according to modern soil-conservation practices.

On the conservation farm, multiflora rose hedges take the place of wire fences; unproductive borders between fields and woods are utilized for strips of bicolor lespedea, silky dogwood, or autumn olive; and permanent field boundaries on the contours are marked with narrow, shrubby hedges. These practices serve useful purposes for the farmer and provide food and cover for farm wildlife.

A 1-acre farm pond rounds out the farm picture. This pond, completed in 1950 and stocked with 100 black bass fingerlings and 750 small bluegills, should provide valuable information on another modern agricultural trend. Such a pond, properly managed, may produce 500 or more pounds of fish per year for the farm family—plus many hours of recreation—in addition to the value of water storage for livestock.

Other wildlife studies involve management of waterfowl habitat; correlation of forestry and wildlife practices; management of small game and fur animals; determination of effects of DDT and other chemicals on wildlife; migration and distribution of waterfowl and other migratory birds; wildlife diseases and epidemics; and the screening of chemicals for rodenticidal value, either as toxicants or repellents.

There are three laboratories on the Refuge. The Nelson Laboratory is headquarters for migration and distribution studies on North American waterfowl and other migratory birds and houses original records of nearly 70 years of investigations by Federal biologists and a corps of civilian cooperators. This is the outstanding working collection of such records in the country and perhaps in the world. Henshaw Laboratory is headquarters for Fish and Wildlife Service investigations on animal diseases and parasites in the eastern United States. The Merriam Laboratory houses the administrative staff and contains a chemical laboratory and quarters for biologists assigned to agricultural wildlife investigations, including waterfowl habitat improvement, management of fur animals in the wild, and effects of chemical control agents on wildlife.

Although independent from the Agricultural Research Center in administration, many activities of the Patuxent Research Refuge are closely allied with those of the Center in contributing to better farm living.
FOREST RESEARCH AND THE EXPERIMENTAL FOREST

Research in forest management, forest-tree breeding, and reforestation is carried on by the Forest Service's Northeastern Forest Experiment Station on a 3,000-acre experimental forest located on the east side of the Research Center. This experimental forest provides opportunity for research under conditions typical of much of the Coastal Plain oak-pine forests of Maryland and adjacent States.

The experimental forest is being used to develop improved cutting methods for the much-abused second-growth oak and pine forests that cover several million acres of poor and worn-out land in this region. How to make forestry profitable is a particularly urgent problem in this timber type, which currently has a relatively low commercial value. Here foresters are studying the possibilities of converting the present inferior oak-pine stands into good forests of more valuable trees. The problems peculiar to owners of woodlots and small forests are being given special attention.

The forest-management studies are aimed primarily at developing financially feasible ways of bringing the forest to higher productivity. Improved logging equipment has been purchased and is in use to process primary products from experimental cuttings and deliver them to the roadside. A cooperative agreement with a wood-using industry provides market outlets. A portable chipper capable of handling small trees, including those cut during thinning, is being tested to determine the economic feasibility of producing chips for such purposes as stock bedding and mulches. The effectiveness of cultural measures to improve immature stands and of harvest cuttings in promoting natural reseeding is being evaluated, along with the relative merits of different logging methods. Repeated inventories of the growing stock on experimental areas form the basis for rating the silvicultural benefits of the several measures.

Some of the Northeastern Forest Experiment Station's forest-tree-breeding research is being conducted on the experimental forest. Major emphasis here is on hybrid poplars, more than 200 strains of which are being tested for disease resistance. The less susceptible clones are propagated for extensive regional tests. Field plantings of poplar, soft maple, and pine hybrids also have been made.

Several tree-planting studies are under way in two difficult situations: one, an area very severely burned in an accidental fire, and the other an area of sterile subsoil exposed in constructing the airport.
Production and Marketing Administration

TESTING COMMERCIAL INSECTICIDES AND OTHER KILLERS

In laboratories, greenhouses, gardens, and orchards located at the Research Center, the Insecticide Division of the Livestock Branch, Production and Marketing Administration, tests samples from interstate shipments of commercial insecticides, fungicides, disinfectants, rodenticides, and weed killers. This Division administers the Federal Insecticide, Fungicide, and Rodenticide Act of June 25, 1947, which is intended to protect farmers, livestock raisers, orchardists, and householders from losses and possible personal injury through faulty, misbranded, or adulterated products. Under the law, all such products must be registered with the United States Department of Agriculture.

GRAIN STANDARDS RESEARCH

Offices and laboratories of the Production and Marketing Administration for conducting standards research are also maintained at the Research Center. Standards have been established for most farm products. Before the formulation of Federal standards for grain about 30 years ago, grain marketing was in a chaotic condition, with a great variety of local standards and no uniformity in their application. Federal grain standards now provide the medium of a common understandable language between buyers and sellers. Official inspection gives an unbiased appraisal of the quality and condition of grain, independent of buyer or seller.

To supply background information for the inspection of grain, the Standards Research and Testing Division of the Grain Branch performs mechanical, chemical, milling, and baking tests on grain. The purpose is both to improve the structure of the standards to meet changing conditions and to work out new and improved methods of evaluation that can be translated into terms of practical inspection service. Similar standardization studies are being made on rice and other farm products, including hops, peas, beans, hay, and straw.

Of major importance have been the development and standardization of mechanical equipment for use in grain-inspection work to eliminate the personal element. This equipment includes a divider that cuts down large samples into aliquot portions for analysis, an improved test-weight-per-bushel apparatus, standard dockage machines for cleaning grain, sieving apparatus for kernel-sizing tests, and rice-shelling devices for determining the milling quality of rough rice.

TESTING MISCELLANEOUS COMMODITIES

The Grain Branch of the Production and Marketing Administration is responsible for inspecting and testing a wide variety of commodities, including flour, cereals, and other grain products, vegetable oils, vitamin products, soaps, and many other commodities purchased by the Commodity Credit Corporation, and for testing certain of these products purchased by the Department of National Defense. Much of this
testing is done at the Research Center, but some of it is done by commercial and other laboratories under the supervision of the Center laboratories.

INSURING SEED QUALITY

Because seeds look more or less alike to laymen, farmers need some assurance that seed they buy will germinate and produce the kinds of plants they have a right to expect from reading the label or advertising statements. To provide this assurance, Congress passed the Federal Seed Act in 1939. This act, enforced by the Production and Marketing Administration, requires complete and truthful labeling of seed shipped in interstate commerce for seeding purposes and prohibits false advertising. It prohibits also the importation of seed that fails to meet certain standards of quality.

To make sure that seedsmen are complying with the law, the Production and Marketing Administration each year examines hundreds of samples of seeds taken from interstate channels of trade by State inspectors under State seed laws. These seeds are tested at the Federal seed-testing laboratory at the Research Center and, under the supervision of this laboratory, at field laboratories in California, Missouri, Minnesota, New Jersey, and Alabama.

Germination tests on these samples reveal the viability of seeds in each shipment. The tests are made by placing a counted number of seeds on moist blotting paper or
towels or in sand or other soil and letting them remain for a number of days in a cabinet kept at the temperature best suited for the germination of that particular kind of seed.

AERIAL PHOTOGRAPHIC NEGATIVES

The Production and Marketing Administration uses space at the Research Center for storage of aerial photographic negatives, used in making the aerial pictures that play an important role in administering the farm program. These photographs are also utilized by the Department of Defense. Photomaps of over 250,000 square miles have been compiled from aerial photographs for the use of the Department of the Army.

More than 18,000 rolls of aerial photographic negatives, each longer than 100 feet and representing altogether pictures of approximately 3,000,000 square miles of land area, are stored in fireproof, air-conditioned vaults. These negatives are taken to the Production and Marketing Administration’s aerial photographic laboratories in Washington for use as needed, then returned to the vaults at the Center for filing and safekeeping.

SCHOOL LUNCH AND PLENTIFUL FOODS

The National School Lunch and Plentiful Foods Programs are administered by the Production and Marketing Administration. Research on recipes and menus for school lunches and plentiful foods and on lunchroom management is conducted by the Bureau of Human Nutrition and Home Economics at the Agricultural Research Center. (See page 28.)
Soil Conservation Service

SOIL AND WATER CONSERVATION

Conservation farming means treating every acre according to its individual needs and using every acre according to its individual capabilities. On a 1,700-acre tract on the south side of the Research Center, the Soil Conservation Service is applying this principle—developing new conservation farming methods, working out improvements of methods and equipment, and studying erosion-resistant plants.

On some fields, rows following natural contours mark experimental plantings. Tests are made of improvements in such conservation practices as contour cultivation, ridge rows, rotations, mulching, and cover crops. Particular attention is devoted to methods of safeguarding the productiveness of the hilly tobacco land of southern Maryland.

Laboratory studies in soil physics help determine the causes of the success or failure of different conservation management practices when applied to different kinds and conditions of soil. These studies deal chiefly with soil-water relationships and the development and maintenance of soil structure.

A National Observational Nursery collects and tests plants for soil and water conservation and other economic values. Because vegetation is fundamental in conservation farming, the Nursery deals with grasses, legumes, and forbs as well as forest and shrub species. These may come from the wild, from abroad, or from cooperating research agencies. Attention is given to vegetative characteristics, fruiting habits, simplicity of reproduction, soil conserving qualities, propagation, seeding, culture, and seed harvesting and processing.

Plants that show superior conservation values are given further trials in regional nurseries and on farms. There, under local conditions, they are checked by farmers or ranchers and technicians alike for farm, range, forest, and wildlife conservation. Once proved, the plants reach farmers and ranchers through regular channels in accordance with regulations governing introduction of new crops.

The Service's Cartographic Division maintains facilities for constructing and reproducing maps, charts, mosaics, aerial and still photographs, and technical drawings. This service unit supplies such materials used by technicians and farmers in making over-all and detailed plans for applying conservation measures.