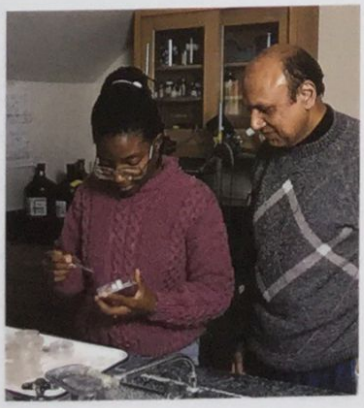
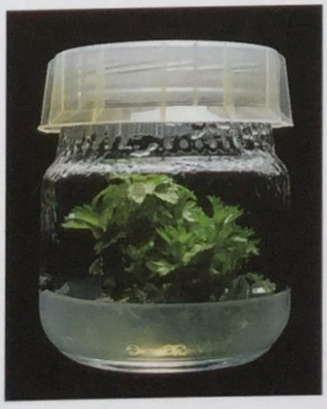
CORNELL UNIVERSITY GENEVA

New York State

AGRICULTURAL EXPERIMENT STATION

A Division of the
New York State College of
Agriculture and Life Sciences
A Statutory College of the State University
at Cornell University





ABOUT OUR COVER

Counterclockwise from above right:
Field work at Fruit and Vegetable Research Farm; Barton Laboratory; adult grape root worm; spring apple blossoms; Seed physiology; Apple tissue culture used for genetic engineering; Hartland sweet cherry.

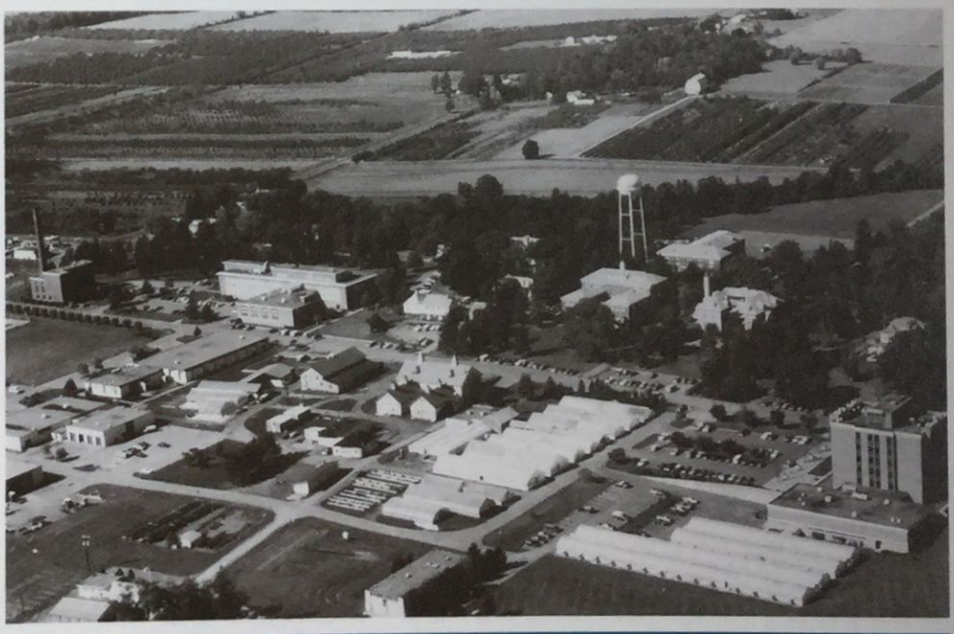
Produced by Communications Services
New York State Agricultural Experiment Station
Cornell University • Geneva
Revised December 1993

CORNELL UNIVERSITY GENEVA

New York State

AGRICULTURAL EXPERIMENT STATION

A Division of the
New York State College of
Agriculture and Life Sciences
A Statutory College of the
State University
at Cornell University



Aerial view of main campus of the Geneva Station.

The second leading fruit crop grown in New York is grapes, one of many fruit and vegetable crops studied at the Station.

INTRODUCTION

Major challenges face New York's agriculture as it moves toward the year 2000. The primary mission of Cornell University's New York State Agricultural Experiment Station at Geneva is to support the New York fruit and vegetable industry with research and extension programs needed to meet these challenges. These programs improve the health of the population by developing good farming and food storage/processing practices that ensure consumers a supply of economical, safe, and high-quality fruits and vegetables. The Station helps maintain a prosperous rural environment by developing and promoting efficient and environmentally sound farming and food processing practices. And, programs at the Station help improve the state's economic climate through enhancement of the competitive position of New York's number one industry—food and agriculture.

In order to meet these challenges, scientists at the Geneva Station use the vast array of "tools" available to them. This includes not only the use of traditional techniques, but such modern-day advances as genetically engineering plants and taking advantage of other benefits available in the fast-developing field of biotechnology. Still, there are many problems that need to be solved in order to ensure a successful agricultural economy in the state. New York faces strong competition from other states and even other parts of the world. Yet, on the other hand, the state is in an enviable position relative to its agricultural economy. It has good soils, a climate conducive to the growing of high-quality fruit and vegetable crops, an ample supply of water,

New York faces strong competition from other states and even other parts of the world.

and a manageable level of insect and disease problems. Also of importance to New York growers is the fact that agricultural products grown in the state are within a one-day's truck ride to more than 65 million people in the United States. Scientists at the Geneva Station are helping growers and food processors cultivate this market through improved ways of producing high-quality fruit and vegetable crops.

HISTORY

The Station was established in 1880 by an Act of the state legislature. It began official operations on March 1, 1882. It has grown from its original house and barns located on 130 acres of land to a complex that includes 20 major buildings plus greenhouses and other ancillary structures and 900 acres of land at Geneva devoted to test plots, orchards, and vineyards. The Station also has two outlying substations, one located in Highland, NY and the other in Fredonia, NY. There are more than 320 full-time employees at the Station, 56 of whom are professors. The budget exceeds $16 million annually, of which approximately 60 per cent is state base-funding.

One of the oldest agricultural research institutes in the country, the Geneva Station is a leader in studies of fruits and vegetables.

The Station is part of the College of Agriculture and Life Sciences of Cornell University. It has been associated with Cornell University since 1923, and today it is also a unit of the State University of New York. Since the 1940s, the Station has focused its research and extension programs on the production, protection, and processing of fruit and vegetable crops.

There are four departments actively engaged in more than 120 projects. These departments are: Horticultural Sciences (study of fruit and vegetable crops, and seeds), Entomology (study of insects and mites), Plant Pathology (study of plant diseases), and Food Science and Technology (study of food processing and packaging techniques and their effects on food quality and safety).

Agriculture is New York's largest business, valued at more than $20 billion annually. Although fewer than two per cent of the population actually till the land producing food and fiber products, agriculture is the basis for employment in many other areas.

RESPONSIBILITIES

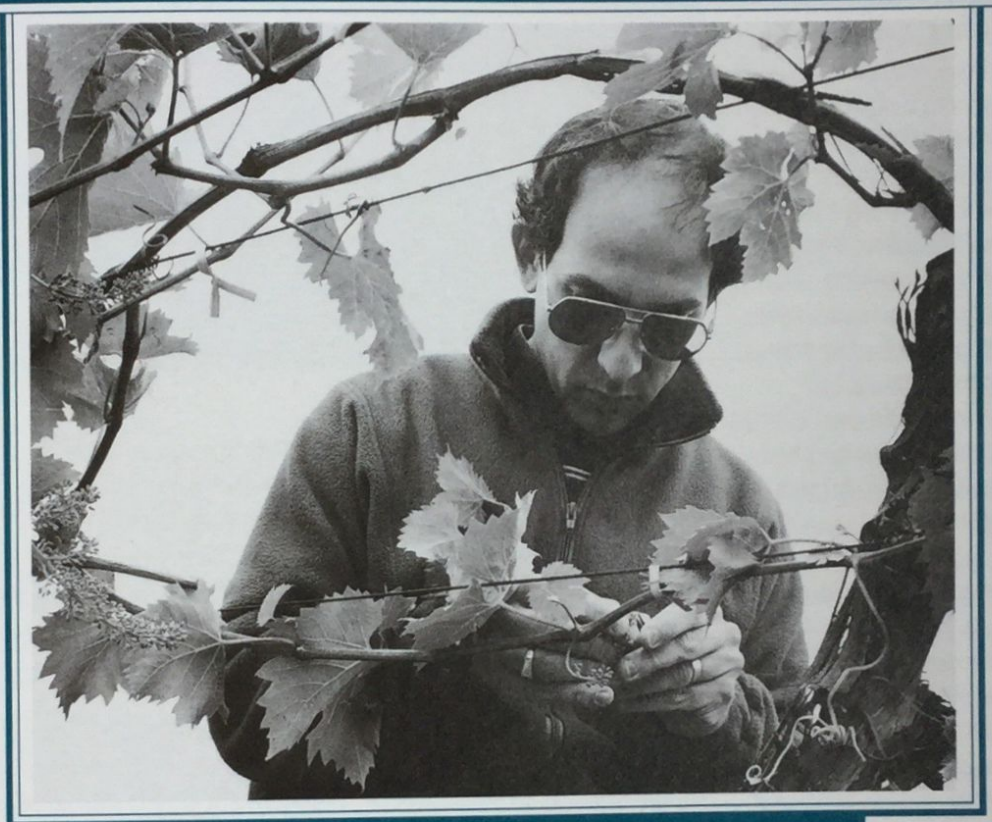
Besides its research programs, the Station maintains a strong cooperative program with the Agricultural Research Service (ARS) of the United States Department of Agriculture. This program is housed in the Plant Genetic Resources Unit, and focuses on the conservation and utilization of the genetic resources of a number of important fruit and vegetable crops. In addition, there are service-related activities such as those performed by the New York State Seed Testing Laboratory; the Feed, Fertilizer Control and Lime Laboratory; and the Pesticide Analytical Laboratory. Also, New York State's Integrated Pest Management program is based at the Station.

Visitors come to the Station from throughout the world to study the research and extension programs.

Research done at Geneva benefits not only New York agriculture and its residents but reaches beyond the state. Many Station faculty are invited to give advice on projects in other countries, particularly in developing nations. These interactions assist farmers to feed the rapidly expanding populations in these regions. They also enhance the quality of programs at the Station in various ways such as improving plant breeding programs through the introduction of valuable germplasm and better understanding the challenges to New York agriculture in a global economy.

Dedication to excellence has made the New York State Agricultural Experiment Station one of the leading horticultural research and extension institutions in the world. Consequently, approximately 20 visiting scientists from throughout the world are usually at the Station at any given time. They will stay for periods ranging from a few months to two or more years. Although most of the faculty do not have classroom teaching responsibilities, at any one time about 90 Cornell graduate students are doing their thesis research at the Station under the direction of its graduate faculty. Additionally, Station faculty are becoming increasingly involved in extension activities. This facilitates the rapid and efficient dissemination of research results to growers and processors. There is a constant exchange of information between scientists at the Station and people in the industry to ensure that the needs of agriculture are addressed and that practical, economical, and beneficial answers are provided.

HORTICULTURAL SCIENCES



Grape breeder inspects fruit-set of seedless table grapes being developed for New York.

The Department of Horticultural Sciences has developed an array of research and extension projects on fruits, vegetables, and seeds. Major emphasis is placed on vegetables, apples, and grapes. In addition to developing improved varieties and breeding lines and improved cultural practices, basic research is conducted in genetics, physiology, biochemistry, and microbiology.

Agricultural crops can be no better than the seed used to produce them. Knowing this, farmers want assurance that the seed they are using is of the highest quality before they incur other expenses involved in planting, growing, and marketing a crop. Seed testing and research at the Geneva Station are vital components of the process to ensure that high quality seed is available to growers in New York state.

Realizing the importance of seed testing, state legislators passed a law establishing a seed testing service at the Geneva Station in 1912. Currently, the Seed Testing Laboratory evaluates approximately 12,000 samples of seed each year from seed lots used for planting crops in the state. In addition to regulatory testing, the Seed Laboratory tests seed for private companies, farmers, and the New York State Certified Seed Association. Purity analyses have been perfected and laboratory germination procedures have been

Professor inspects newly developed glossy-leafed cabbage that is resistant to feeding by insect larvae.

developed for seeds of hundreds of species of field crops, vegetables, flowers, turf, trees, and shrubs.

Station seed researchers study the life processes of many kinds of seeds. Physiologists are studying a variety of treatments that result in earlier emergence, uniform stands, and vigorous seedlings. Microbiologists are developing biological control methods for seedborne microorganisms that cause diseases in crops grown from these seeds.

Research on vegetable crops has been part of Experiment Station programs since 1882. Currently, this research includes a wide range of breeding and genetic programs, as well as studies of cultural practices and the biochemistry and physiology of yield and quality. Primary emphasis is placed on vegetables grown for processing. Among the primary breeding objectives are disease and insect resistance, improved yield and quality, and adaptation to mechanization. Improved breeding lines rather than finished varieties are the principal products of the vegetable breeding program. These lines are made available to commercial seed companies to complete the development of new varieties and produce seeds for growers. Utilizing new biotechnologies for the department's genetic improvement effort has resulted in great strides in developing virus resistant lettuce and squash, and in conducting genetic analysis of peas.

Major emphasis is placed on vegetables, apples, and grapes.

Horticulturists and physiologists are studying various soil-plant-water-atmosphere relationships as they influence growth and development of vegetables. Studying a plant's heat and cold tolerance, ability to absorb and utilize nutrients, and its manufacture of naturally occurring hormones all give researchers information vital to reducing yield fluctuations. Efficient use of fertilizers is critical to farming costs and retaining good quality ground water.

Developing improved tree fruit varieties and more efficient cultivation practices to help maintain a viable and competitive industry are the objectives of the tree fruit breeding program in the department. Intensive research is conducted on the tree itself, its fruit, and rootstocks. Breeding, physiology, and cultural management studies are integrated to produce recommendations for cultivation of new varieties.

Every year, apple breeders make controlled pollinations in efforts to combine the best characteristics of diversified parents into new varieties. The best selections are made available for commercial and home garden use. Seven Geneva introductions are among the top 20 varieties being planted in New York: Empire, Cortland, Macoun, Jonamac, Monroe, Jonagold, and Spigold. Introduced in 1966, the Empire apple is being planted more frequently than any other variety except Red Delicious.

The objectives of the Station's grape breeding program are to develop varieties that produce superior wine, juice, and table grapes.

Controlling infectious diseases in New York state apple orchards is expensive. An internationally recognized cooperative project between Horticultural Sciences and Plant Pathology focuses on the development of varieties that are resistant or tolerant to the four major diseases affecting New York apples (apple scab, powdery mildew, fire blight, and cedar apple rust). Using disease-resistant varieties can reduce growers' costs and the amount of fungicides introduced into the environment. The first new variety to be released from this program, Liberty, was introduced in 1978. A second variety, Freedom, was released in 1984 and requires no fungicide sprays to control these diseases except under the most severe conditions.

New York apple orchards are changing from the age of 30-foot high trees that had to be picked with tall ladders to much smaller trees that are planted close together and intensively managed. The size of the tree is controlled by the rootstock onto which it is grafted. A part of the Station breeding program is devoted to developing size-limiting, multiple disease-resistant rootstocks specifically adapted to New York. Research is also under way on controlling vegetative growth and shaping tree canopies to optimize fruit quality and production.

Several projects at the Station are directed toward creating new opportunities for the grape industry. The objectives of the Station's grape breeding program are to develop varieties that produce superior wine, juice, and table grapes. To ensure sustained growth, the wine industry must be supplied with grape varieties that can be used to make wines that compete in the marketplace. New varieties like Cayuga White and Chardonnel plus new wine products are creating new business opportunities. Besides quality, new varieties should have resistance to fungal diseases (powdery mildew, downy mildew, and black rot); have roots resistant to phylloxera, an important insect pest; and be able to withstand New York's cold winters. They must also be adapted to mechanical harvesting.

In the past 30 years, the average yield of grapes in New York has increased from 1.5 to more than 4 tons per acre. Much of this increase is the result of research on management practices such as balanced pruning, vine spacing, weed control, and vine nutrition. A training system called the Geneva Double Curtain doubled the per acre yields of grapes over traditional training systems. Other major contributions from this research include the development of the principle of mechanical harvesting and mechanical pruning of grapevines.

Recently, Station researchers have focused attention on combating the problems encountered by viticulturists growing European grape varieties in New York's cold winters. These approaches include modified cultural practices geared toward reducing and dealing with the problems caused by cold weather.

Scientists apply polymer film coating to seeds that enhances seed protectant activity and controls water uptake.

Controlled pollination of apples to produce the next generation of disease-resistant apple seedlings.

The table grape industry requires a better understanding of how to grow, harvest, and market varieties like Concord, Himrod, and Delaware. Also, new seedless varieties that have improved quality as well as better cluster and berry size are essential for this natural snack. New varieties are being bred that extend the harvest season and retain fresh characteristics during storage. In recent years, special emphasis has been placed on the production of winter-hardy seedless types. Einset Seedless is an exciting variety recently released by the Station.

The small-fruit breeding effort at Geneva continues to be successful. Commonly planted strawberry varieties that came from the Station program are Honeoye, Catskill, and Fletcher. Of the new strawberry varieties, Jewel is becoming the standard of the industry, and Seneca, shows great promise.

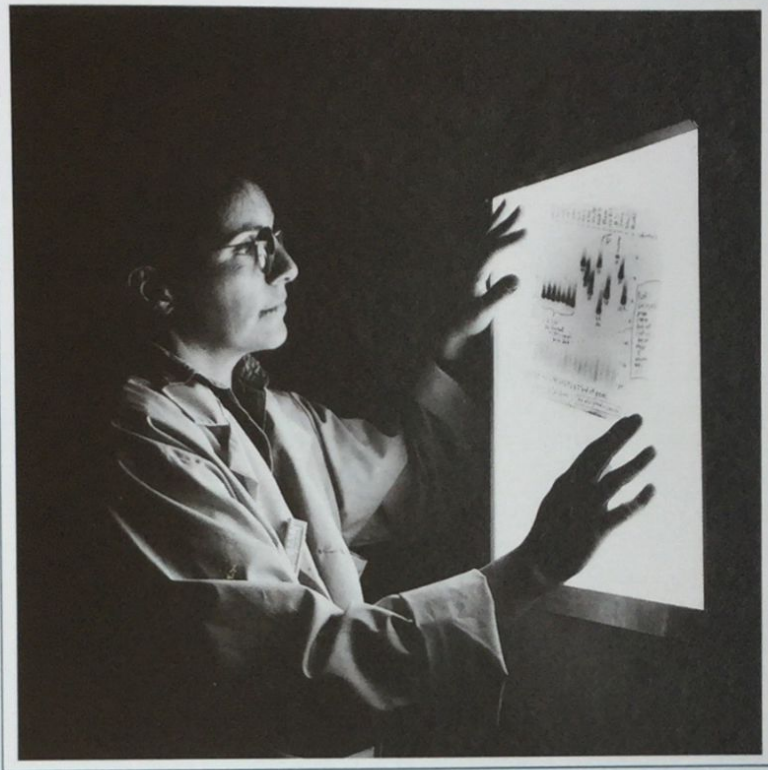
Heritage, a primocane fruiting red raspberry released in 1969, has provided a unique management advantage to raspberry growers using it as a fall-bearer. Titan, introduced in 1985 by Station researchers, is currently being propagated using tissue culture techniques to increase its vigor in the early years of establishment.

The new tools of biotechnology offer exciting possibilities for improving horticultural crops. Studies at the Geneva Station are focusing on improving techniques to culture tissues and cells of apples, grapes, and raspberries in test tubes. Scientists are mapping the chromosomes of fruits and vegetables so they can find desirable genes to use in improving varieties.

The Department has been deeply involved with variety evaluation since the 1880s and is recognized throughout the world as one of the major centers for this work. Extensive collections are maintained of many fruits and vegetables that may have value for the commercial or the home grower, or as parents in the breeding programs. In addition, collections of apples and grapes native to the United States are being made to ensure that their special attributes are preserved for future scientific needs.

Breeding, physiology, and cultural management studies are integrated to produce recommendations for cultivation of new varieties.

ENTOMOLOGY



Insect DNA visualized by autoradiography in molecular biology program.

The primary mission of the Department of Entomology at Geneva is to establish effective, economical, and environmentally safe systems to control insects and mites that attack horticultural crops grown in New York. To assure sustainability, multi-strategy control systems must be developed. These pest control systems must not only control pests below economically damaging levels, but be biologically sound and allow for a reasonable profit to be made on the crops being protected.

Research is conducted on chemical pesticides as well as biologically based strategies. The goal of the pesticide management research is to increase efficacy while reducing associated risks. Research on alternative or biologically based strategies provides the ecological basis essential for sustainability. It involves research on basic principles for the development of new pest control strategies, as well as commodity-based research. In meeting our mission, the department is cognizant of, and answerable to, our constituents—the farmer, the processor and greater agro-industry, and the consumer.

Applied research involves developing methodologies for evaluating, monitoring, and limiting immediate problems associated with insects and mites. To the benefit of New York agriculture, applied research has been successfully pursued at Geneva for many years and will continue to be so. However, as history has shown us, present day tactics will become outdated, and we must constantly look for new solutions to our pest problems. To develop solutions to long-range problems, the department devotes a portion of its resources to basic research in insect and mite biochemistry,

Applied research involves methodologies for evaluating, monitoring, and regulating immediate problems associated with insects and mites.

physiology, ecology, behavior, and molecular genetics. Through a purposeful assembly of a talented and dedicated staff, the blend of applied and basic research in this department has proven highly successful. It is our objective to maintain this balanced approach in reaching our crop protection goals.

Entomologists at Geneva with commodity responsibilities focus particularly on the management of pests on vegetables and fruit crops and turf. Programs on vegetable crops concentrate on the biology, ecology, and management of selected insect pests. For several important vegetable crops, sampling strategies and monitoring tools have been developed to help growers determine the abundance of a pest species. In association with these strategies, entomologists working on vegetable crops have developed insect population-threshold guidelines to help growers determine when treatments are needed.

The present strategies rely on the use of effective synthetic or biological insecticides. Entomologists also are investigating strategies to prevent insects from finding and colonizing vegetables. These efforts have succeeded in identifying plant lines and cultivars resistant to serious pests, and in understanding the chemical and ecological factors that influence the ability of the insect to find its host plant. Additionally, research is conducted on ways to manage insect pests through biological control methods such as the use of beneficial insects and nematodes, natural and genetically engineered pathogens, and behavior-modifying chemicals. There is a constant search for new alternatives to the present management strategies to provide environmentally and economically sound recommendations to the growers.

A major emphasis in the department is on insect and mite pests of grapes, apples, pears, and small-fruit crops. The programs involve research on the behavior, biology, and control of the insects found on these crops. Because apple maggot is the key pest in apple orchards in New York State, the control of this pest is intensively targeted. In small-fruit crops, efforts are concentrated on the tarnished plant bug, the strawberry bud weevil, and the strawberry root weevils. There also are studies on the dynamics of arthropod predator/prey and parasitoid/host systems, the distribution and movement of arthropods within and between host crops, and the development of accurate and efficient systems for making pest management decisions. Other efforts are centered on the development and use of techniques for monitoring pest resistance to pesticides. Still others concentrate on studying insect viruses and other pathogens that can be used to

Scientist testing a new insect virus as an environmentally safe pesticide.

Apple maggot populations monitored with baited sticky red spheres that attract the adult flies.

control insects. These genetically engineered organisms have been shown to be able to infect and eventually kill certain insects that attack crucifers such as cabbage. A program focused on grape pests involves research on the development of sampling schemes and thresholds, biotic and abiotic factors that influence pest development and distribution, and optimization of both chemical and nonchemical control practices. Another program has the primary responsibility for advising and educating fruit growers about insect and mite problems and their control. The efforts focus on the evaluation of sampling and monitoring techniques for assessment of control options, and on relating current pesticide application methods to existing pest control guidelines.

The department has a strong program on the ecology and control of insects that attack roots of turf and horticultural crops. These studies focus on the biotic and abiotic factors affecting the behavior and survival of insects within the soil environment, with particular attention directed to a complex of scarab beetle species whose larvae damage a wide range of food and cash crops.

Basic research programs are developed to address pest management problems identified in the applied programs. In one program, research is conducted on the mode of action, pharmacokinetics, and metabolic fate of toxic chemicals in insects and nontarget organisms; mechanisms of insect resistance to insecticides; and the biochemistry of detoxification and selective toxicity. In a cooperative effort with the molecular genetics program, research is under way to clone and sequence genes that confer resistance to pesticides and to define the molecular basis for resistance. This research has an objective of developing mechanism-based molecular probes and other sensitive detection tools for use in monitoring and managing resistance.

The molecular genetics program provides a basis for other cooperative efforts in the department that involve the use of molecular genetic techniques. One such effort is the development of a novel class of insect control agents that use elements of the insect genome to disrupt specific metabolic processes of target insects.

A chemical communication program seeks to learn how insects use chemicals to communicate with other members of their species.

A chemical communication program seeks to learn how insects use chemicals to communicate with other members of their species.

A chemical communication program seeks to learn how insects use chemicals to communicate with other members of their species. This involves characterizing genes that encode key enzymes and hormones involved in the production of sex-attractant chemicals (pheromones) in female moths. This long-term investigation of chemical communication complements other studies designed to understand not only how pheromones are produced and perceived, but also how to use them to attract insects to traps so that populations can be monitored. Studies are also conducted to learn how to control insects by continuously releasing pheromones into the air so males cannot locate females for mating.

A major emphasis in the department is on insect and mite pests of grapes, apples, pears, and small fruit.

Insect/plant interactions are the basis of another program designed to identify biochemical mechanisms by which horticulturally important plants resist colonization or damage by pest insects. Efforts are under way to understand the chemistry and biological activity of plant-derived toxicants and growth regulators in insects; determine the identity, synthesis, and regulation of phytochemicals that make plants resistant to insect attack; and to learn how to isolate and characterize plant genes useful in breeding insect-resistant varieties.

Tools of the trade of the soil-insect ecology research group at the Experiment Station. The primary focus of the group is the ecology and management of scarab grubs in turfgrass and other economically important horticultural commodities.

Research on developing new varieties of fruit and vegetable crops, especially apple and cabbage, that are resistant to invasion by insects is progressing. Close cooperation is maintained with plant breeders in horticultural sciences. This research is being assisted by the procedures that exist in the area of biotechnology.

The close interaction of programs within the Department of Entomology provides a strong base for developing integrated pest management systems through cooperative efforts with staff in other disciplines and the Integrated Pest Management (IPM) Support Group located on the Geneva campus.

PLANT PATHOLOGY

Professor inoculating tomatoes to evaluate resistance to anthracnose disease.

It is the responsibility of the Department of Plant Pathology to solve disease problems on New York's fruit and vegetable crops using economical methods that ensure a safe food supply and protect the environment. The department fulfills its mission by pursuing a comprehensive program of research and extension in close cooperation with other Cornell departments at Geneva and Ithaca, and with the College's IPM program.

The major areas of study within the department include etiology, the study of the cause of diseases; epidemiology, the study of how diseases spread and develop in plant populations; and the control of diseases of fruit and vegetable crops caused by fungi, viruses, bacteria, mycoplasmas, and nematodes. Other important areas include developing disease-resistant varieties of crops by conventional breeding and genetic engineering methods; biological control; IPM; and cell biology, biochemistry, and molecular biology of plant-pathogen interactions.

The Department is housed in a modern research building containing laboratories that are well-equipped for all plant pathology techniques. There are specialized facilities for molecular biology; monoclonal and polyclonal antibody production; plant tissue culture and DNA-transformation; scanning and transmission electron microscopy; and computer-analyzed fluorescence light microscopy.

Biological control is receiving increasing attention.

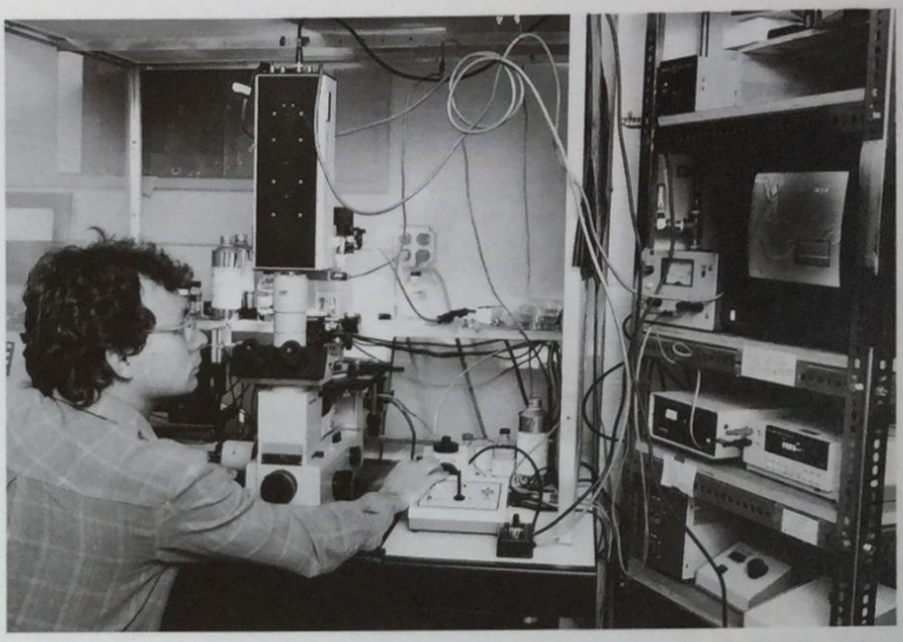
Effective control measures have been developed for many pathogens, but significant research efforts continue to improve and refine methods, particularly in light of heightened concerns about the effect of pesticides on public health and the environment. Initiatives are needed frequently to address new diseases that arise on crops grown in the state. Work is in progress to develop control programs using knowledge of pathogen biology and the infection process, resistant varieties, cultural practices, and plant pharmaceuticals that reduce incidence and severity of diseases. Biological control (the use of a beneficial organism to control a pathogen or pest) is receiving increasing attention as a benign alternative or supplement to conventional methods. In practice, a combination of several different methods is often used to control a disease or to manage it at tolerable levels. This concept of integrated pest management (IPM) is a core philosophy in the Department and is implemented in conjunction with the IPM Support Group at Geneva.

Several researchers in the department are determining the effect of weather and other environmental factors on the behavior of pathogens, crops and diseases. Results of these epidemiological studies, together with information on the activity and performance of fungicides, are critical to the formulation of more efficient control strategies for the future.

Chemical fungicides are still needed for economic production of many fruit and vegetable crops. They are evaluated by our staff, with the goal of replacing older, less effective chemicals with newer pharmaceuticals, which at very low doses will specifically inhibit the pathogens while minimizing contamination of the environment and risk to humans and wildlife. Knowing how pharmaceuticals function in relation to infection of plants is necessary to use them efficiently and safely. Studies are made to determine how to use these pharmaceuticals in such a way that the pathogens do not become resistant to them. The Department is undertaking major efforts to develop non-chemical alternatives, as well as new "biorational" fungicides (those that target biological processes or chemicals present in fungi but absent in higher forms of life).

Research on diseases of the roots of vegetable and fruit crops grown in New York has led to the development of a program on the ecology, biology, and control of soilborne plant pathogens. This work involves identifying the pathogens, be they fungi, bacteria, or nematodes, and determining the role of each in the development of the diseases. This information is utilized to devise various approaches to controlling diseases, including planting disease-

Pruning grapevines used in studies of the biology and control of grape diseases.



Graduate student microinjecting cells of a plant pathogenic fungus to determine how cells change to infect plants.

resistant varieties or rootstocks, altering the physical environment of the soil through cultural practices, and using chemical or biological pesticides as seed and soil treatments.

Control of pathogens with antagonistic microorganisms provides a promising approach to controlling plant diseases. Promising results have been obtained with apple scab, grape powdery mildew, crown gall, root rots, and nematode pests of several crops. Field trials of several of these biological controls are under way.

Research on the crown gall disease of grapevines has shown that the causal bacterium can survive systemically in symptomless grape canes, trunks, and roots. Canes used for propagation of vines may be infected with the pathogen and, therefore, may spread it to new vineyards. Since the bacterium has not been detected in non-vineyard soils, planting of clean vines may be an effective strategy for control of crown gall. Methods have been developed for detecting the bacterium in grapevines using a specific monoclonal antibody and DNA probes. These make it possible to index propagation material to assure that it is free of the pathogen. Pathogen-free grapevines can be produced using tissue culture methods, and hot-water treatments are being tested for eradicating the pathogen from propagation material.

Serological tests that are specific and fast have been developed to detect grapevine leafroll virus.

Considerable research is done in the department on virus diseases of deciduous fruit trees, grapes, berry crops, and vegetables. This research involves identifying the viruses, determining their manner and rate of spread, and developing techniques to determine rapidly the presence of viruses in plant tissues. Such studies provide a base of knowledge for investigators to use in devising strategies for control. Many of the virus diseases of woody plants can be controlled by planting virus-free plants. Thus, the department does research to develop methods to detect viruses in plants and cooperates closely with the New York State Department of Agriculture and Markets, which certifies that nursery plants being sold to New York fruit growers are free of viruses.

One success story of this cooperative effort is on grapevine leafroll. It is the most widespread and economically important viral disease of grapevines. Since there are currently no known vectors of the virus, control of leafroll is largely dependent on the use of healthy plants when establishing new vineyards. Determining if the plants are carrying the virus has traditionally been done by grafting the plants onto woody indicator plants, which need to grow for two to three years before typical symptoms appear. Serological tests that are specific and fast have been developed to detect grapevine leafroll virus. To do these tests, the responsible agent for leafroll was isolated and an antiserum to it prepared. Antisera are now available to rapidly index for the presence of grapevine leafroll.

Senior Research Associate checking growth of genetically transformed apple plants.

The department's virology program also includes basic research into the genetics of viruses and their interaction with susceptible and resistant hosts. Research has shown that mild strains of viruses can be used to "cross protect" (immunize) plants against a more virulent disease-causing strain of the virus. This technique is being used with several virus diseases. Cross-protection by using genetic engineering techniques to introduce coat protein genes of viruses into plants is also being successfully pursued.

Breeding and selecting new fruit varieties with resistance to diseases is a major program conducted cooperatively with breeders in the Department of Horticultural Sciences. Emphasis is centered on development of apple varieties with resistance to the primary diseases affecting apple in New York. Another project is under way to develop apple rootstocks with resistance to crown rot and fire blight. Grapes and berry crops with multiple disease resistance are also being developed.

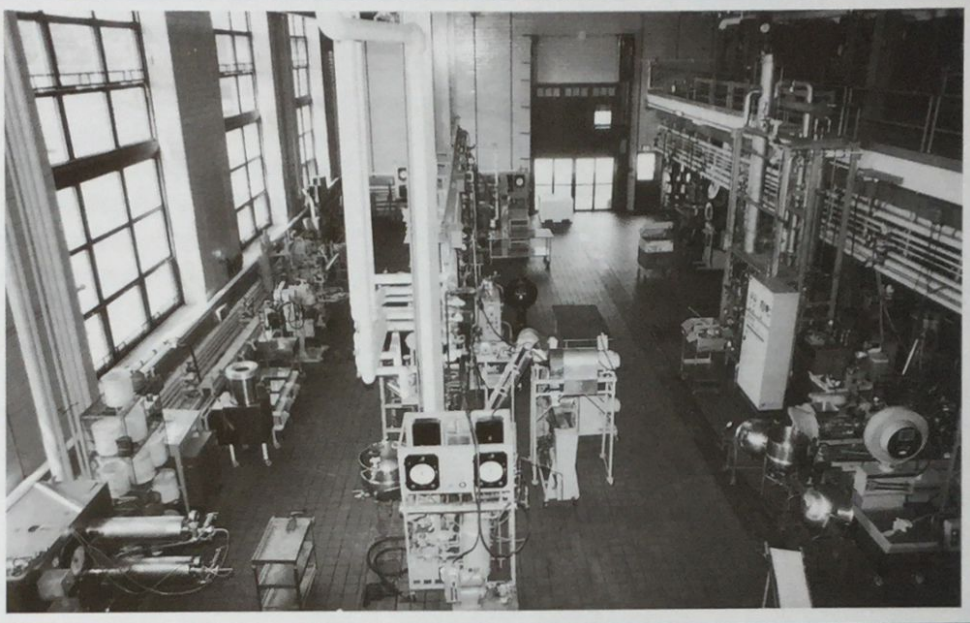
Besides production of disease-resistant plants by conventional breeding, the introduction of various genes into several fruit and vegetable crops by genetic engineering techniques using both *Agrobacterium tumefaciens* and the gene gun as DNA vectors is a very active area of research. This work involves plant tissue culture, gene cloning, transformation, and plant regeneration. Tissue culture plants are also being used in studies of disease resistance, and in propagation of new disease-resistant varieties and rootstocks.

Working closely with vegetable breeders at the Station, plant pathologists are contributing to the development of disease-resistant breeding lines. The main role of the pathologist in these studies is to develop methods to inoculate plants, to identify sources of resistance, to study races of the pathogens that can overcome resistance, to determine how the resistance is inherited, and to evaluate the effects of the environment, especially weather, on the development of disease. This is a long-term effort to identify sources of resistance and to provide the background information needed to aid plant breeders in developing resistant varieties.

The introduction of various genes into several fruit and vegetable crops by genetic engineering techniques is a very active area of research.

An integrated pest management scheme for each crop is the unifying force binding together the research projects of the Department. Cooperation with other departments and with the IPM Support Group at Geneva is leading to the development of effective IPM programs for the fruit and vegetable crops of New York.

FOOD SCIENCE & TECHNOLOGY



Food processing pilot plant where small batches of raw products can be processed into various forms.

The Department of Food Science and Technology covers a broad range of disciplines and a range of activities that mainly begin just after the harvesting of fruits and vegetables and continue through their consumption. Department faculty are not only interested in the plants, storage, processing, and packaging of the products, but also in assessing food quality and safety. Some of these interests lead back to the effects of the variety and growing conditions on the ultimate product. Cooperative studies with other Station researchers in evaluating new varieties and comparing the effects of different horticultural practices on them are a significant component of the department's activities.

Some investigations deal with questions of basic science while others focus on practical problems of the food industry. The primary objectives are to provide the consumer with safe, high-quality food at a reasonable cost and to enable New York's food industry to be competitive nationally and internationally. These goals are achieved through research efforts that apply the principles of plant physiology, chemistry, biochemistry, physics, microbiology, engineering, nutrition, sensory science, and toxicology.

Extension programs convey research findings to processors and consumers, and help in solving processing problems. A number of short courses and workshops are presented to train industry personnel and to facilitate interaction between scientists and

Department faculty are interested in the plants, storage, processing, and packaging of the products, and in assessing food quality and safety.

members of industry. The department's Food Venture Center assists individuals and small companies who wish to bring new food products to market. Much of the help involves providing information on government regulations, but assistance with evaluation, scale-up and, if necessary, reformulation is also provided.

Food technologists and food engineers are mainly concerned with the study of new and conventional processing procedures and problems. Much of their work is carried out in the department's 10,000 square foot pilot plant. For example, the processing specialists apply the principles of heat transfer, rheology, and flow dynamics to improve freezing, filtration, filling, and retorting processes, or for the design of new systems like hot filling of plastic film pouches.

Microbiologists are concerned with both the harmful and the beneficial roles of microorganisms on foods. One phase of the research deals with prevention of spoilage of foods caused by yeasts, molds, and bacteria. Another is to make certain that the microorganisms responsible for food-borne diseases are eliminated from fruit and vegetable products. These goals are achieved through processing or by formulating food products to present an unfavorable environment for microorganisms to grow. Although much of this research is conducted in the laboratory, some of the work is performed in commercial processing plants. Important research challenges for microbiological safety are caused by the recent trend to packaged fresh and lightly processed fruits and vegetables.

Several faculty members study fermentation of food by microorganisms. Their objective is to improve the quality of foods such as sauerkraut, pickles, and wine by developing improved strains of microorganisms or by modifying the fermentation process. This is the classical type of "Biotechnology." Wine research and extension is a major program that includes studies of wine-making procedures and evaluation of existing and newly developed *Vitis vinifera* (French-type) and hybrid wine-grapes for production of various types of wine. The Wine Analysis Laboratory carries out flavor evaluations and analytical work on juices and wines submitted for analysis by wineries and provides advice to wine makers.

A new biotechnology interest is the use of microorganisms to convert food processing wastes into products of economic value. A process was developed, for example, for growing yeast in sauerkraut brine, a waste liquid. The yeasts produce a valuable enzyme, and the fermentation reduces the problem of brine disposal. Research on the fermentation of apple and grape pomaces, which are solid wastes, has shown that they can be used for the production of alcohol or citric acid. Thus, the processes permit the producers of juices and wines to manufacture high-value products from what were previously waste products.

Analyst detects and describes separated aroma components from a food sample using gas chromatography-olfactometry.

An electrophoresis gel is loaded with a nucleic acid sample related to apple tissue softening.

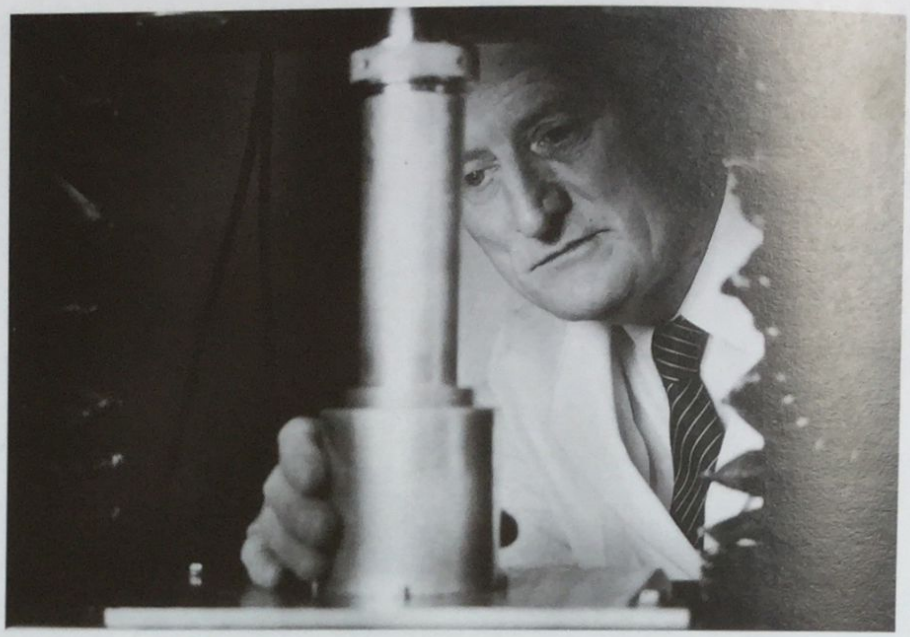
Throughout the harvesting, processing, storage, and marketing chain, food products undergo numerous chemical changes. These changes affect the color, flavor, texture, and nutritive quality of the food. Food chemists study these changes in quality characteristics and the factors influencing them. Because of the biological diversity of fruits and vegetables, staff with different specialties within the science of chemistry are involved in carrying out this research.

Flavor chemists seek to learn which of numerous compounds in fruits and vegetables are responsible for the flavor of each product. Often tiny amounts of a few substances are responsible for the flavor of a food. The way in which these compounds are formed and how they are influenced by processing is also of interest. Flavor chemistry and other work on food quality is enhanced by the use of sensory analysis. This involves using people to evaluate the taste, smell, color, or texture of foods or food ingredients as members of sensory evaluation panels.

Extension programs convey research findings to processors and consumers, and help in solving processing problems.

Biochemists in the department study the chemistry of fruits and vegetables in relation to processing and quality. Part of this research is concerned with biopolymers such as proteins and polysaccharides. Pectins and other polysaccharides are responsible for much of the structure and texture of plant materials. Pectins are also used to cause jellies to solidify. Proteins are important components of foam and haze in juices and other beverages. Some proteins are enzymes, many of which have important effects on food quality. Enzymes with particular properties are purposely added to foods, such as grapes, to increase yield when the fruit is pressed, while others facilitate the clarification of juice. Other enzymes, such as those in vegetables, must be inactivated to prevent undesirable changes in color, flavor, and texture when these foods are frozen.

The colors produced by the various pigments in fruits and vegetables are also of interest to food chemists. Research on the green chlorophylls of peas, the red and purple anthocyanins of grapes, and the yellow-orange carotenoids of carrots and squash is conducted with the goal of achieving better color retention during the processing and storage of these foods. Browning of some fruits and vegetables when the tissue is cut or crushed is often a problem. This is caused by reactions between phenolic compounds and a certain enzyme. Ways in which browning can be minimized are being investigated.



Assessment of vegetable texture using a strength-of-materials testing instrument.

The study of factors affecting the structure and texture of fruits and vegetables requires scientists with strong backgrounds in plant physiology, biochemistry, and physical measurement. Some work on the genetic basis of texture in fruits is also in progress. Since texture affects food acceptability, procedures are being developed to measure and control properties such as "crispness," "firmness," and "graininess" of canned, frozen, and stored foods. Studies employing physical measurement of firmness have led to crisper canned vegetables.

The wholesomeness and safety of processed foods are important research topics. The effects of processing and storage on important nutrients such as vitamins C and D are being investigated by chemists. The toxicology program is concerned with natural toxic substances in fruits and vegetables as well as the protective activity of certain vegetables against diseases such as cancer. The effects of environmental contaminants on food safety is also part of the toxicology program.

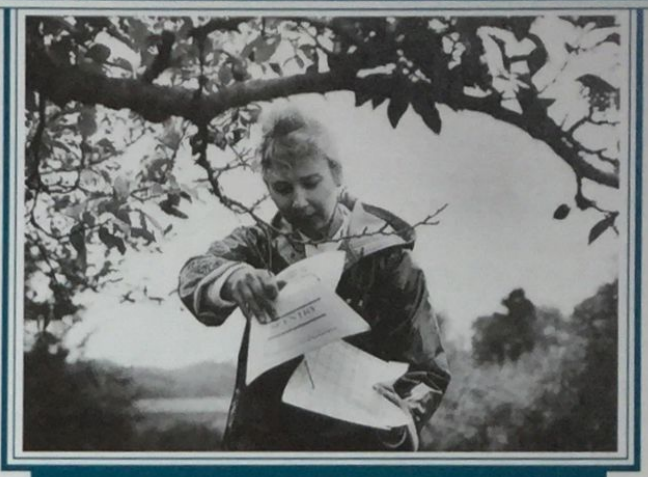
A new biotechnology interest is the use of microorganisms to convert food processing wastes into products of economic value.

The department houses the Pesticide Research Laboratory, which serves as the Northeast Regional Pesticide Laboratory. Personnel in this laboratory work closely with the United States Department of Agriculture, the Environmental Protection Agency, the Federal Food and Drug Administration, and the New York State Departments of Environmental Conservation and Agriculture and Markets to ensure the development of effective and safe pest control programs. These objectives are furthered by participation in the national program for registering pesticides for use on minor crops. The laboratory is also involved in research to develop new analytical methods for pesticides and in studies on contamination of ground water by agricultural chemicals.

The department operates the Feed, Fertilizer, and Lime Control Laboratory in cooperation with the New York State Department of Agriculture and Markets, which uses data obtained from this laboratory in enforcing state regulations covering these products. The laboratory staff is currently analyzing feeds for drugs as well as for nutrients, and conducts tests to determine if fertilizers and liming materials are of their stated compositions.

▾INTEGRATED▾ PEST MANAGEMENT

Concern over agricultural chemicals in the environment and restrictions on their use pose a challenge for our society, which is accustomed to plentiful, blemish-free food. The College's Integrated Pest Management (IPM) Program, which is based on the Geneva campus, has been addressing that challenge since 1973.



Extension specialist checks pheromone trap for the presence of crop-damaging insects.

The IPM Program helps agricultural producers to reduce their reliance on chemical pesticides through its yearly funding of research projects. These projects that lead to the development of new IPM strategies are carried out by Cornell scientists in plant pathology, entomology, horticultural sciences, and other disciplines who develop improved methods of pest management for fruits, vegetables, ornamentals, and dairy/field crops.

These new methods are extended to growers by Cornell Cooperative Extension field staff, IPM specialists, and pest scouts hired to assist with IPM-funded implementation projects. Growers who participate in these pilot projects usually rotate their crops, plant pest-resistant varieties, monitor crops regularly for pests, and identify pests. They also commonly use cultural controls such as sanitation, preserve natural enemies by using least-toxic and biorational pesticides, and use conventional chemical pesticides judiciously by not spraying until pest populations reach a critical level.

The IPM Program helps agricultural producers to reduce their reliance on chemical pesticides through its yearly funding of research projects that lead to the development of new IPM strategies.

The growers who participate in IPM projects gradually assume the full cost of their program, and many growers continue using IPM practices after the Cornell project has culminated. Growers desiring to learn about IPM on their own can choose from the dozen IPM manuals and videotapes or the hundreds of other publications produced by the program in the last few years.

To date, every major agricultural region in the state has benefitted from IPM efforts. Growers using IPM practices continue to produce high quality, marketable products with a minimum of pesticides, and the program continues to expand into additional crops and regions.

Parasitoids released from this cheesecloth bag will attack fly pupae in dairy barns, significantly decreasing the need for insecticide treatments.

PLANT GENETIC RESOURCES UNIT

Technician prepares a DNA sample for molecular analysis of *Brassica* accessions.

Efforts to preserve important breeding material of fruits and vegetables are greatly strengthened through a cooperative arrangement with the USDA-ARS Plant Genetic Resources Unit (PGRU) that is located on the campus of the Geneva Station. The PGRU includes three components: the Northeast Regional Plant Introduction Station (NERPIS), the National Germplasm Repository for Apple and Cold-Hardy Grape (NGR), and the Research Support Group. Major germplasm collections (collections of plants with different genes) include tomato, apple, crucifers, clover, grape, onion, birdsfoot trefoil, winter squash, timothy, and buckwheat.

Both NERPIS and NGR have responsibility for the acquisition, maintenance, characterization, and distribution of the genetic resources in their collections. This germplasm, stored under strictly controlled conditions on campus as well as living collections on Station farms, constitutes an irreplaceable national resource. It is the biotic raw material essential for continued genetic improvement of crops. Accessions from the collections are freely distributed to research programs worldwide. Scientists from the PGRU also participate in a number of cooperative research activities at the Station and locations throughout the United States. In addition, the Research Support Group conducts problem-oriented research on the nature of genetic diversity, using an array of whole-plant, biochemical, and molecular approaches. The overall goal is to develop strategies and techniques that can be employed to maintain maximum useful disease-free genetic diversity in its collections.

The Research Support Group conducts problem-oriented research on the nature of genetic diversity, using an array of whole-plant, biochemical, and molecular approaches.

Examining cabbage plants in the PGRU's controlled pollination and seed regeneration nursery.

▼ BRANCH SUBSTATIONS ▼

The Station's Hudson Valley Laboratory is located at Highland, New York in Ulster County. It was established to assist the fruit and vegetable growers in eastern New York. The Laboratory maintains 24 acres of land for research plus laboratory and greenhouse facilities. Much of the research is conducted in conjunction with local growers. The laboratory building and the land on which the building is situated are owned by the Hudson Valley Research Laboratory, Inc. (a grower-owned organization) and are rented by the Experiment Station. Three faculty and an eight-member support staff are permanently located at the Laboratory to deal with the unique problems facing growers in that particular region of the state.

Hudson Valley Laboratory

The Geneva Station is also responsible for conducting programs at its Vineyard Research Laboratory located in Fredonia, which is southwest of Buffalo. This Laboratory was established by an Act of the State Legislature in April 1909. A seven-member staff is housed in a building named the Taschenberg Laboratory. The facility has 30 acres of land available for research. A significant amount of the Station's cultivation and plant protection research on grapes is done at this Laboratory. Three grape extension personnel are housed at this facility. Growers and processors provide significant financial resources to help support research and extension programs at this Laboratory.

Vineyard Research Laboratory

SPECIAL SUPPORT UNITS

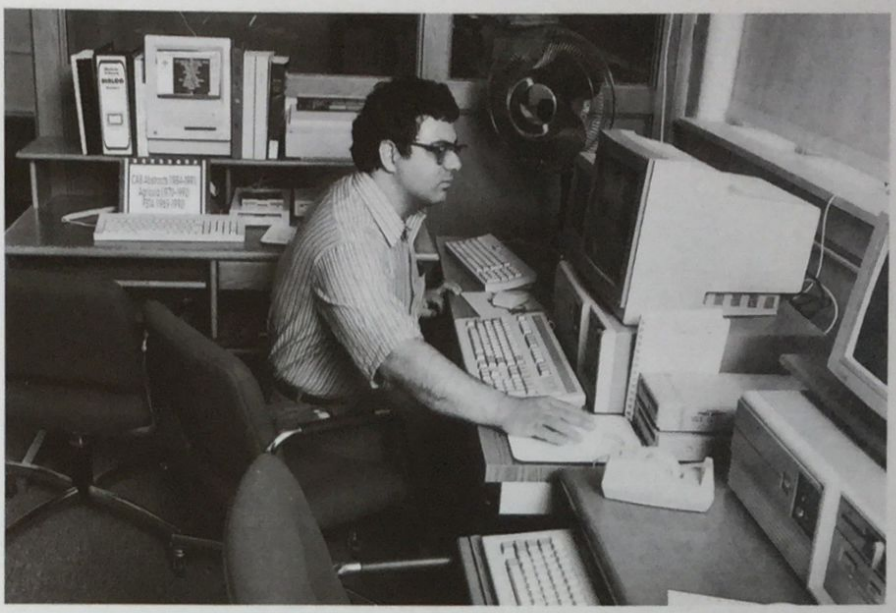
There are several essential support services provided for the research and extension programs at the Experiment Station.

COMPUTER CENTER

Computing is an important adjunct to both research and administrative activities at the Station. Time-shared computing is provided by a computer manufactured by Sun Microsystems, Inc. The time-sharing system supports a range of standard programming languages, programs for statistical analysis (Genstat, GLIM, Minitab, MLP, SAS,SPLUS), genetical analysis, and the standard internet activities (electronic mail, FTP, Telnet). Over 300 personal computers, primarily Apple Macintosh models, are present on campus. An Ethernet network provides interconnection between all Station computers and also connection to the main Cornell campus and the worldwide networks. In addition to computer services, the Computer Center provides Telex and facsimile services for the Experiment Station.

With more than 300 personal computers on campus, the repair service offered by the Computer Center is very important.

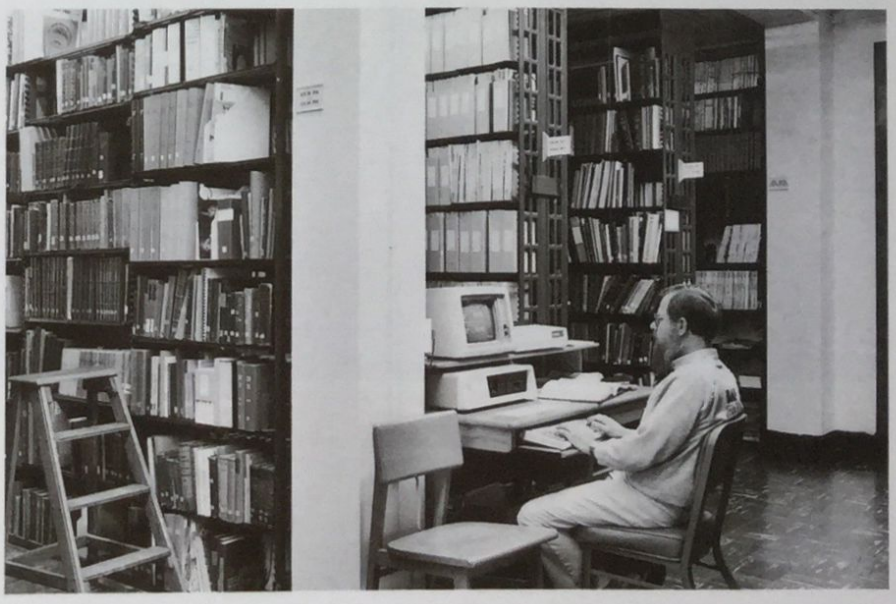
Director of Computer Center assists faculty, staff, and graduate students with the statistical analysis of data.



Multiple access to electronic resources is one of the strengths of the Geneva Library.

LIBRARY

The Station's Library consists of approximately 59,000 volumes (books and bound journals) and receives about 1,000 current journals. The strengths of the Library are its compactness, accessibility, and relevance to Station programs. Strong collections in the special areas of research carried out at the Station emphasize agriculture, with wide coverage of related fields such as biochemistry, molecular biology, and genetics. Additional special features include an Interlibrary loan system for accessing research materials not owned by the Station; NOTIS, an on-line catalog system providing access to holdings of all Cornell University libraries; Electronic databases on CD-ROM; Mann Library Gateway, which is an information system developed to provide Cornell students, faculty, and staff with access to scholarly electronic databases; and Dialog, a commercial data bank containing hundreds of databases.



Researchers using one of many computer systems in the Library.

The entire gamut of communications services are provided so that the faculty can provide latest results of research to their various audiences.

COMMUNICATIONS SERVICES

A communications unit at the Station provides editorial, publication, graphic, photographic, and video services to the faculty, staff, and graduate students. Station publications are distributed to the scientific community, growers, processors, cooperative extension personnel, and the general public. This unit is also responsible for the public information program of the Station, including creating and developing exhibits, media materials, and other public information activities. Computer-generated slides are prepared by the unit for use in research and extension presentations.

Many exhibits are prepared annually for both scientific and grower/processor meetings.

About 900 acres of field plots are maintained for faculty, staff, and graduate students to use.

FIELD RESEARCH UNIT

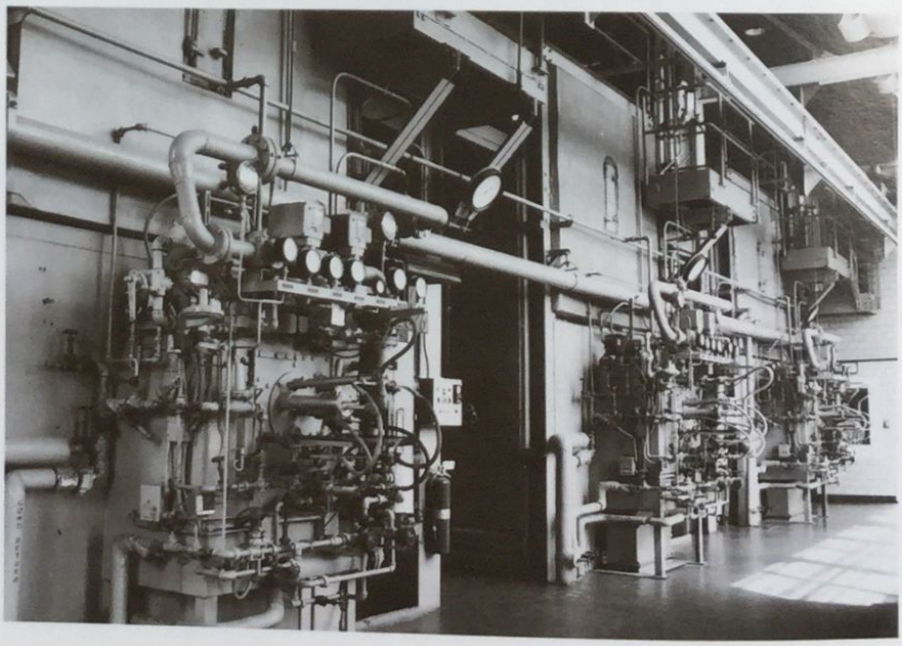
This unit provides services to all departments at the Station. It operates and maintains one acre of greenhouse space that is used to supplement field and laboratory research programs. Greenhouses are temperature controlled by computers and have had energy efficient materials installed to reduce operating costs significantly. The unit is also responsible for maintaining the Station's 900 acres of land used for field research programs. In addition the unit maintains the grounds of the main campus.

Keeping the more than 50 acres of the main campus groomed is the responsibility of the greenhouse and grounds crew of the Field Research Unit.

Maintaining the many buildings on campus and on the farms is critical to the smooth operation of the research and extension programs.

BUILDINGS AND PROPERTIES

This unit is responsible for maintaining the buildings, equipment, and vehicles of the Station and providing custodial services, telecommunications installations and repair, and security. In addition, they are responsible for operating the heating plant to generate steam used for heating and cooling throughout the campus. Approximately 40 individuals are employed in the Buildings and Properties unit.



Boiler fronts at the Central Heating Plant.