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The Mann Laboratory: A Half Century of Postharvest Research

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The Davis campus of the University of California (UC) is internationally renowned for its research, teaching, and extension programs in agricultural and related biological sciences. This reputation was earned primarily by scientists and educators in the Colleges of Agricultural and Environmental Sciences, in the College of Biological Sciences, and in the Davis component of the Agricultural Experiment Station and Cooperative Extension. UC Davis has the world's largest grouping of plant scientists, and they are distributed among the departments of Agricultural and Resource Economics, Biological and Agricultural Engineering, Entomology and Nematology, Food Science and Technology, Nutrition, Plant Pathology, Plant Sciences, Viticulture and Enology, and other related departments.

The Davis Campus

The diversified 2145-ha (5300-acre) Davis campus was established in 1905 as a branch of the College of Agriculture at UC Berkeley. In 1952, the UC Davis College of Agriculture became independent of programs on the Berkeley campus. UC Davis is now one of ten UC campuses and has continued to expand and broaden its research and educational programs to become the most comprehensive campus of the UC system. UC Davis currently serves 35,400 students in 104 majors within its four colleges (Agricultural and Environmental Sciences, Biological Sciences, Engineering, and Letters and Sciences), in the 99 programs in the Graduate School, and around 5500 students in the professional schools of Education, Law, Management, Nursing, Medicine, and Veterinary Medicine.

UC Davis is located in the fertile Central Valley of California, 15 miles west of the state capital of Sacramento. It is within a 2-h drive to the San Francisco Bay Area, Lake Tahoe, and Napa Valley, and is adjacent to the city of Davis, a friendly community of 68,000.

The Mann Laboratory

The successful production and marketing of fresh horticultural crops requires knowledge and practice of postharvest principles. UC Davis was among the first U.S. land-grant institutions to dedicate resources to research and extension work in postharvest biology and technology. Postharvest research in the Department of Truck Crops (later renamed the Department of Vegetable Crops, and later incorporated into the Department of Plant Sciences) began in the 1920s. The need for larger and better equipped physical facilities became obvious as early as the 1940s. Lobbying and financial support by the Western Growers and Shippers Association and grants from the state of California and from the National Science Foundation resulted in the establishment of the Mann Laboratory.

Fifty years ago, on 22 Mar. 1967, the newly constructed Louis K. Mann Laboratory was dedicated to postharvest physiological studies of fresh horticultural crops and to the training of students in postharvest biology and technology. The Mann Laboratory is part of the Department of Plant Sciences in the College of Agricultural and Environmental Sciences. The facility was named after Dr. Louis K. Mann, an accomplished scientist and a dedicated scholar and teacher in the Department of Vegetable Crops for more than 20 years. His research included studies on the taxonomy, morphology, culture, and flavor chemistry of onions and their allies; pollination and fruit development of melons and tomatoes; and the postharvest physiology of onions, garlic, and sweetpotatoes. His untimely death in 1964 was a great loss to horticultural science.

The Mann Laboratory initially included 16 walk-in controlled-temperature rooms, three large access and preparation areas, three research laboratories, eight offices, a conference/library room, and a large undeveloped area for future expansion. In 1991, the building underwent extensive renovation, with the undeveloped space reconfigured into a teaching laboratory, three research laboratories, two workshops, and three offices for students, postdoctorates, and visiting scientists. These modifications accompanied a shift from more field-oriented to more laboratory-oriented research.

During the past 50 years, many eminent plant scientists from around the globe have been attracted by the personnel and facilities to conduct research at the Mann Laboratory. In the past half century, more than 200 graduate students and postdoctorates have studied at the Mann Laboratory. Many of these scientists have become recognized leaders in the field of postharvest biology and technology around the world.

The Mann Laboratory currently houses some of the postharvest scientists in the UC Davis Postharvest Program for the Biology and Technology of Horticultural Crops. This program includes faculty in eight UC Davis departments and additional faculty in four departments at UC Riverside. UC Davis postharvest scientists offer upper division and graduate courses that lead to an MS degree offered by individual departments or to a PhD degree in the interdepartmental graduate groups of: Biochemistry, Molecular, Cellular and Developmental Biology; Horticulture and Agronomy; Molecular, Cellular and Integrative Physiology; and Plant Biology. The program coordinates a quarterly graduate level seminar on postharvest biology and technology.

Postharvest Research

The benefits of postharvest research are readily apparent to producers, shippers, and consumers. Any grower or producer who has suffered an economic loss during marketing or any consumer who has disposed of tasteless or poor-quality fruits and vegetables can readily appreciate the importance of preserving quality from harvest to consumption. California grows a large proportion of the fruits, vegetables, and ornamentals marketed in the United States and ships a substantial quantity of fresh produce to foreign markets. Traditional postharvest storage and evaluation studies have been instrumental in delineating the conditions required to maintain quality in the storage, transport, and marketing of perishable crops. The Mann Laboratory was specifically given the charge to supplement these traditional investigations with physiological and biochemical studies to develop a basic understanding of postharvest biology and to formulate procedure and technologies to maintain the quality of harvested fresh produce.

Former Mann Laboratory Faculty

All of the original five Mann Laboratory faculty have long since retired. The original faculty included Robert Kasmire, Leonard Morris, Harlan Pratt, Lawrence Rappaport, and Shang Fa Yang. Other occupants have either retired while at the Mann Laboratory (Donald Nevins, Michael Reid, and Mikal Saltveit) or have moved on to different positions, locations, or both (Joe Ahrens, Alan Bennett, Kent Bradford, and Jim Lyons).

Over the years, the focus of research by Mann Laboratory faculty shifted from studies of practical postharvest significance (e.g., optimal storage temperatures and controlled atmospheres) to basic studies of biochemical and physiological changes taking place after harvest (e.g., genes and enzymes responsible for softening during fruit ripening, the synthesis and action of ethylene, responses to abiotic stresses, and food safety and security). Because the Mann Laboratory was initially part of the Department of Vegetable Crops, early research focused on postharvest disorders of asparagus, lettuce, melons, and tomatoes. Later, as the UC Davis postharvest program consolidated, research included fruit and floricultural crops, and seeds.

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Researchers in the Mann Laboratory have always balanced research on basic postharvest problems with the need to extend their results to solve practical commercial problems. Some important areas that have benefited from research by Mann Laboratory faculty include: the cause and prevention of chilling injury, the synthesis and action of ethylene, the molecular biology of fruit ripening, and the physiological basis of controlled and modified atmospheres. The contributions of some former faculty are described below.

Shang Fa Yang and colleagues made outstanding contributions to our basic understanding of the mechanism and regulation of ethylene biosynthesis and action. Along with his graduate student Douglas Adams, he identified the immediate precursor in the biosynthesis of ethylene (i.e., 1-aminocyclopropane-1-carboxylic acid). Later, his group discovered how recycling of the organosulfur ''thio'' group permitted continued ethylene biosynthesis (i.e., the Yang cycle). Their research led to the development of techniques to manipulate ethylene biosynthesis and action in the process of plant senescence and in relation to environmental stress.

Michael Reid and colleagues demonstrated that nonclimacteric tissues, including oranges, potatoes, and other root crops, experienced a respiratory climacteric when exposed to low concentrations of ethylene. This climacteric was associated with conversion of starch to sugar, a serious storage disorder of potatoes. Later, their molecular studies of the nonclimacteric flower, *Mirabilis jalapa*, identified a range of genes associated with floral senescence. One highly upregulated gene was a component of the 26S proteasome, suggesting that the proteasome was involved in protein turnover during the onset of senescence. Flower life was greatly extended when the upregulation of the subunit was inhibited using an inducible promoter driving an RNAi construct.

Mikal Saltveit and colleagues elucidated the role of stress-induced phenolic metabolism in postharvest disorders and devised novel ways to use the tissue's own hierarchical responses to stresses to ameliorate the response to other abiotic stresses. Diverting protein synthesis from those induced by wounding or chilling to the production of innocuous heat-shock proteins greatly alleviated the undesirable responses to other abiotic stresses; e.g., they were the first to show that induction of heat-shock proteins increased chilling tolerance. They also showed that climacteric fruit did not exhibit a rise in respiration if ripened on the plant. The climacteric burst in respiration coincident with the ripening of harvested climacteric fruit may be an artifact of harvest, and not a necessary phenomenon associated with ripening of climacteric fruit.

Donald Nevins and colleagues studied the primary structural elements in fruit cell walls that are responsible for the changes in texture accompanying ripening. They also developed a detailed view of the complex carbohydrate structure of the monocot plant cell wall. Their multidisciplinary approach focused on the biophysical mechanisms accommodating cell extension that leads to changes in fruit texture during ripening. Their research included transgenic plants where putative ripening-related enzymes were altered in expression.

Alan Bennett and colleagues helped clarify the molecular biology interactions between softening during fruit ripening and its role in disease susceptibility. By enhancing and promoting the processes that limit the decomposition of unripe fruit and identifying and then limiting the ripening processes that facilitate the breakdown of ripe fruit, they were able to improve the quality of harvested fruit. They focused on the interaction between *Botrytis cinerea* and tomato fruit but also investigate rotting caused by pathogens known to infect tomato products in California.

Kent Bradford and colleagues focused on diverse aspects of seed germination biology. They developed hydrothermal time models to describe germination behavior, analyzed the roles of plant hormones in regulating germination, and identified and cloned genes involved in the germination process.

Current Mann Laboratory Faculty

Barbara Blanco-Ulate studies the regulation of fruit ripening and susceptibility to fungal pathogens. Her research team integrates systems biology approaches with biochemical and physiological analyses to study fruit physiology and to establish a novel framework for the early detection and efficient management of postharvest diseases. They also apply this integrative approach to investigate other postharvest traits, such as fruit softening, nutritional value, and sensory attributes. Most of the Blanco Laboratory research will be initially focused on tomatoes and strawberries, which represent economically valuable postharvest commodities worldwide and particularly in California.

Marita Cantwell is the Cooperative Extension Vegetable Specialist focusing on identifying and solving problems related to harvesting, cooling, storing, and handling of fresh-market vegetables. Her program emphasizes the quality and postharvest behavior of vegetables as affected by variety, preharvest cultural practices, and postharvest handling procedures. She is recognized for her applied research and extension work on the storage requirements for specialty vegetables and fresh-cut products.

Cai-Zhong Jiang is an Adjunct Professor in the Crops Pathology and Genetic Research Unit of the USDA, Agricultural Research Service. His group conducts research on postharvest issues relating to ornamentals. Postharvest losses and poor quality of ornamental crops are often caused by earlier leaf and flower senescence and abscission. His team uses molecular and genetic approaches to identify key transcriptional regulators and to elucidate signaling pathways that regulate these traits. His laboratory is also developing technologies to improve drought tolerance/resistance for ornamental plants by focusing on molecular manipulation of plant hormones that play an important role in the plant's response to water stress. These novel techniques to manipulate leaf and flower senescence and abscission and drought resistance, will improve the postharvest performance of ornamentals.

Maeli Melotto specializes in plant-pathogen interactions. Food production is constantly threatened by pathogenic microbes that can decrease crop yield and contaminate the edible parts of the plant. Her research is focused on understanding the close interaction between plants and pathogen at the molecular level. Her group aims to determine the physiological changes that happen in both the plant and the pathogen when they come into contact. Their major effort is geared toward discovering how the plant immune system works to fight against pathogen infection and elucidating the virulence strategies employed by pathogens to overcome plant defenses. This line of research is critical for the development of environmentally sound methods to minimize not only the impact of diseases and economic losses in agriculture worldwide, but also food contamination with human pathogens.

Trevor Suslow is the Extension Research Specialist who focuses on the quality and safety of perishable horticultural commodities. His program involves preharvest and postharvest research, extension, and outreach education on diverse fresh and fresh-cut horticultural foods. While his research activities still involve applied postharvest quality and decay control, the emphasis of his program has been dominated by issues of microbial safety and disinfection within the preharvest and postharvest environment. The primary research emphasis has included controlled and open-environment research on human pathogens, nonpathogenic indicators, or approved attenuated surrogates of enterohemorrhagic and shigatoxn-producing *E. coli*, *Salmonella enterica*, and *Listeria monocytogenes*. Recent studies have emphasis microbial source tracking, survival, persistence, dispersal, improvements in pathogen detection systems, and comparative genetic subtyping of transient and resident *L. monocytogenes* in postharvest handling facilities.

Mann Laboratory

The Mann Laboratory will continue to be a place where dedicated researchers, students, and colleagues produce innovative research to address the need to provide a safe and reliable supply of nutritious fresh produce. For further information about the Mann Laboratory or the UC Davis Postharvest Biology Program please visit the UC Davis Postharvest Technology site at http://postharvest.ucdavis.edu.

Front Cover: The Mann Laboratory. Back Cover: Researchers and students in the Mann Laboratory. Photo credits: Front cover Debbie van Blankenship; back cover Lee Ann Richmond, designed by Mikal Saltveit.