THE PIONEER EXPERIMENT STATION 1875 to 1975

A HISTORY

BY

JAMES G. HORSFALL

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JAMES G. HORSFALL was born in Mountain Grove, Missouri in 1905 and grew up in Monticello, Arkansas. He was the son of Margaret Vaulx Horsfall and Frank Horsfall, founder and director of the Monticello School for gifted high school students from south Arkansas. Years later this school became a campus of the University of Arkansas.

After graduating from the University of Arkansas at Fayetteville, the author migrated to New York State, where he received a PhD from Cornell University. During his second year at Cornell, his high school sweetheart, Sue Belle Overton, boarded a train in Pine Bluff, Arkansas for Buffalo, New York. James met her train and married her that same day at Niagara Falls. Ithaca winters nearly defeated James's southern "belle," but she survived and earned her keep and his keep also by teaching first grade at the Forest Homes school in Ithaca. The couple owned an old Model T Ford named Napoleon that they always parked on a hill with the front end facing down to better use the "gravity feed" starter. Napoleon referred not to the famous Frenchman but to the car whose bones were always apart.

With a fresh PhD, James moved to the department of Plant Pathology at the Cornell Experiment Station in Geneva, New York. Sue Belle worked as a dietician and food service director at the Geneva High School, and in 1931 I was born. My sister, Anne Horsfall Thomas, arrived five years later in 1936. Unfortunately for me but perhaps fortunately for science, I suffered from a series of childhood ailments, including virulent ear infections. As a young child, I was one of the pioneer children to achieve good health because of sulfa drugs that cured my ear aches and even my scarlet fever. Always alert for new ideas, my father asked himself if perhaps organic compounds could also cure plant diseases. They could. Thus he and others started down the road that led to the birth of the organic fungicides that are still used around the world.

The dedication of my father from 1939 until 1975 to the "soul" of the Experiment Station in New Haven is amply documented in this book. For him, however, active and productive life continued long after he retired. The five volume treatise on *Plant Disease* edited by him and Ellis Cowling of North Carolina University and published by Academic Press in 1977-1980 was truly a "cathedral" to the glory of the science of plant pathology. The State of Connecticut appointed him chair of the blue ribbon committee that wrote *An Environmental Policy for Connecticut*. For this achievement, the *New Haven Register* named him Connecticut Citizen of the Year.

The present volume on the pioneer station was completed after my father entered his 88th year.

Margaret Horsfall Schadler
EDITOR

BOULDER WITH BRONZE PLAQUE
COMMEMORATING THE STATION'S 75TH ANNIVERSARY

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Preface

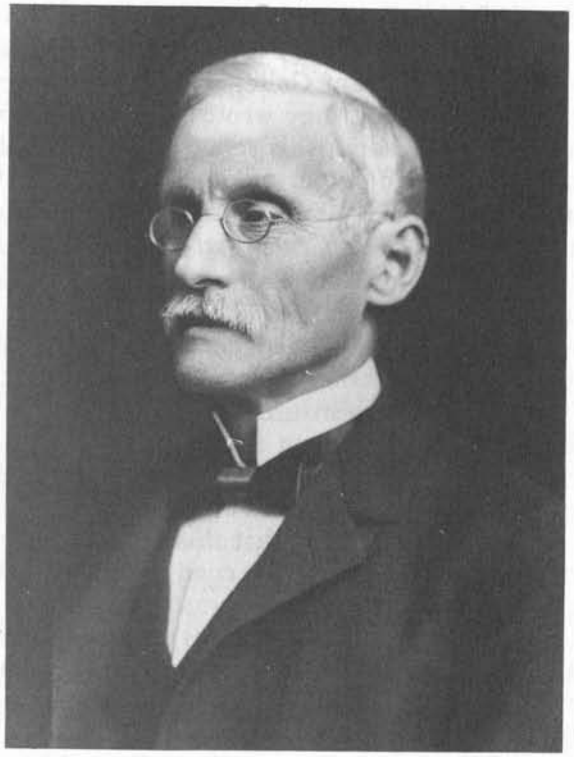
The Connecticut Agricultural Experiment Station, being the first in the nation, has a rendezvous with destiny; hence its history must be written, even by an amateur. The story will begin at the beginning and end with 1975, the centennial year. The first part of the book is based on an article I wrote for the New Haven Colony Historical Society, which granted permission to reprint it.[1]

It is easy to claim that the station was the first Agricultural Experiment Station in the Country. Do others confirm this? True said so in his 1937 history of experiment stations,[2] and so also said Knoblauch *et al.* in their history written for the occasion of the centennial of the Land Grant Colleges in 1963. In discussing the role of Samuel W. Johnson, they wrote, "Johnson's first success in his ardent advocacy [of Stations] is reflected in the establishment ... of America's pioneering Experiment Station, The Connecticut Agricultural Experiment Station."[3] A more recent historian, Kerr, states in his 1987 book, *A Centennial of the State Agricultural Experiment Stations*: "The Nation's first facility to be designated as an agricultural experiment station was born in 1875.... The debt to the German Model was acknowledged by the literal translation of *Landwirtschaftliche Versuchsstation* (agricultural research station) as the title of the first research institution."[4]

To establish priority, one must define the concept at hand. What was the nature of the German model? Its basic characteristics were: first, that it was established by action of the local legislature; second, that it was tax supported; third, that it was an independent public corporation; fourth, that it was governed by a board that included farmers; and fifth (negatively) that it was not a part of a university. After 1875, the legislatures of many states set up experiment stations on the Connecticut model – an independent, tax-supported agency. These states were North Carolina (1877), Massachusetts (1878), New York (1880), New Jersey (1880), Ohio (1882), and Maine (1883).

Other states followed the pattern of a station within a university. These were California (1877), Cornell (1879), Tennessee (1882), Alabama (1883), Wisconsin (1883), Vermont (1886), and Louisiana (1886). Thus fourteen stations had been established by 1886. This encouraged the Congress in 1887 to pass the Hatch Act, which provided funds for an experiment station in every State. With the implementation of the Hatch Act, the directors of the new stations founded the Association of Land Grant Colleges and Experiment Stations. Samuel W. Johnson, of the Connecticut station, was elected president of this Association in 1896.

One needs much sympathetic help in writing a history like this one. I am grateful for the help of numerous colleagues. Thank you all. I wish to thank particularly my daughter, Dr. Margaret H. Schadler for her generous editorial help.



Samuel W. Johnson

1830 – 1909

Founder and first director of first Station.

Professor at Yale. Introduced experiment station idea in America.

1

The Gestation Period

One is fascinated by the concatenation of circumstances that led to the birth of the Nation's first Station. What were the societal and scientific factors that converged in the office of Governor Charles R. Ingersoll when he signed the bill for its creation on July 20, 1875? Why was the Station established in Connecticut? Who worked to establish it?

The Station was an invention for making inventions. Its major invention, of course, was the mechanism of putting science to work for society. It would help to thwart Malthus. The invention would enable the Nation to move from an agrarian frontier society to a sophisticated city society. It would change agriculture from a largely subsistence operation to one in which a single farmer can feed more than fifty persons. Subsequent chapters will list some of the detailed inventions.

In 1950, on the occasion of the Station's diamond jubilee, the Connecticut Development Commission awarded it a bronze plaque as "The First Agricultural Experiment Station in America." (See frontispiece.) In 1964 the nation recognized the importance of the Station with a bronze plaque making it a National Historic site.

An organization so revolutionary in thought as an agricultural experiment station – did not just jump spontaneously out of the woodwork. Like many other advances in thought, it was created when someone related two hitherto unrelated things. It was created first in the mind of Samuel W. Johnson, who related science to agriculture. To relate them in his mind was not enough, of course. He had to have the vision, the shrewdness, the doggedness, the conviction, and the persuasiveness to make it go.

THE AGRICULTURAL FACTORS

It is a fair question to ask, "Why did the first station come to rest in Connecticut? Why not in Pennsylvania, the bailiwick of Benjamin Franklin, or in Virginia, the home of Washington and Jefferson, both experimenting farmers? Why not in New York State, which now spends more on agricultural research per unit of farm income than any other state?"

All the seaboard states had land as poor as that in Connecticut. A native of New York State, why did Johnson not establish his station there? Like Connecticut, New York had a state Agricultural Society; it supported two farm papers, but it had no college where chemistry could be applied to agriculture.

When Johnson became professor of agricultural chemistry at Yale in 1855, Cornell University was still but a gleam in Ezra's eye. At

Yale, Johnson found a platform from which he could proclaim the advantages to accrue from an agricultural experiment station. And his position was greatly enhanced in 1863, when Yale became the Land Grant College of Connecticut.

The idea of experimental agriculture by no means originated with Johnson. In 1733, a century and a half before Johnson's station, Oglethorpe had established an experimental garden in Savannah, Georgia. A historical plaque, there today, calls it the first experiment station. It survived for only ten years, however.

For at least two thirds of its three hundred and fifty odd years, Connecticut was an agricultural state. Agriculture in those days was largely subsistence agriculture. It took eighty farmers to feed twenty city people – doctors, lawyers, factory workers. Except for the bottom of pre-glacial Lake Hartford, land in Connecticut was poor. Because river valley land is richer than hill land, colonial settlers farmed that first. When the valleys became occupied, the farmers had to move up the hillsides onto much less fertile land. By 1754 all the usable agricultural land was under the plow, and something had to give as the population grew.

This forced the inventive Yankees to search for other means of livelihood. They turned to water power from the streams pouring down from their hills and began manufacturing. This opened new jobs for the farmers' sons, who left the land and became consumers rather than producers of food. This did not raise the fertility of the soil, however. It merely raised the cost of a hired man on the farm and made it more difficult to feed the cities.

Despite the growing power of industry, farmers maintained a strong influence on the legislature. In 1726, for example, the General Assembly of Connecticut passed an extraordinary law to benefit agriculture. Farmers knew somehow that barberries were bad for wheat, even though they did not know why. (The scientific explanation for this came 154 years later.) The law said that barberries must be eradicated.

ACTION OF SOME SCHOLARLY CITIZENS

At about this time some scholarly citizens, ministers, doctors, manufacturers, and lawyers began to worry about the food situation in the State.

As early as 1760, Jared Eliot, a minister, did his bit by publishing the first book on agriculture in America – *Essays of Field Husbandry.*[5] A few years later, in 1763, Ezra Stiles, president of Yale, urged silk farming. In 1794 the farmers formed the "Society for Promoting Agriculture." The American Revolution had induced an agricultural revolution in Connecticut, opening vast new lands to the west. They were rich, level, and stone free. Connecticut farmers deserted their stony fields and went west with their wives, their children, their cattle, and chattels. The handwriting was on the agricultural wall.

Henry Ellsworth, a Windsor lawyer and gentleman farmer whose uncle had signed the Declaration of Independence, went to Washington in 1855 to set up the patent office, but pushed so hard for agriculture that his office became the Department of Agriculture.

In 1845, S. L. Gold, a physician of Cornwall, hoped to help by establishing the Cream Hill School for farm boys, one of the first in the Nation.

In 1853, Orange Judd, a wealthy book publisher and student of Johnson at Yale, contributed by buying and publishing the *American Agriculturist* magazine.

These were some of the giants of Connecticut and what they did during the gestation of the Station. In the 1840's, these citizens had become conditioned to listen to the siren song of science as it would be sung by the Sillimans, Norton, and Johnson. This we shall now tune in.

THE SCIENTIFIC FACTORS

Nineteenth century science was built on the eighteenth century foundations of Lavoisier, Priestley, Newton, Linnaeus, Voltaire, and Laplace. The contemporaries of the Sillimans, Norton, and Johnson – men like Joule, Maxwell, Faraday, Kelvin, van't Hoff, Wohler, Boussingault, Darwin, Pasteur, and Mendel – extended the scope and accelerated the pace of research. Science was clearly on the move in the nineteenth century, and those who would make it possible to study agriculture scientifically were moving with it.

BENJAMIN SILLIMAN. When Silliman graduated from Yale in 1802, he intended to be a lawyer; in fact, he passed the law examination. But Timothy Dwight, President of Yale, had other ideas for this bright young man. He persuaded Silliman to be a chemist, sending him to Philadelphia to study chemistry at the University of Pennsylvania Medical School. When he was but twenty-three years old, he was made professor of Chemistry and Natural History at Yale.

Silliman promoted geology, mineralogy, and natural history as well as chemistry. He became a charter member of the National Academy of Sciences in 1863 and played a role in the second meeting of the Academy in New Haven in 1864.

JAMES F. W. JOHNSTON played a role from his position in Scotland. He was professor of Chemistry at Durham University in England, but in 1843 he took on a moonlighting job as chemist for the newly formed Agricultural and Highland Association of Scotland. His funds came from assessments of the members. He initiated agricultural experiments and paid for his research by analyzing fertilizers to prevent fraud.

Johnston set forth a policy that would one day appear in the Charter of the Station: "Who is to undertake [the research] I have named," he asked, emphasizing that research should not be left to a college. "The proper function of a college is to teach – not to investigate."

JOHN PITKIN NORTON played his part, too, though unfortunately for only a short time. The son of a wealthy lawyer and farmer, he went in 1840 to Silliman at Yale to learn how he might apply chemistry to agriculture. Silliman, having traveled in Scotland earlier, and having heard about Johnston's new idea for applying science to agriculture, sent Norton to work with him for two years. Norton then wrote home to the *Albany Cultivator* that his country should establish such a research agency.

As the Scots used oats to make hay for their horses and porridge for their breakfasts, it seemed fitting that Norton should undertake research and publish a paper on the protein of the oat kernel.

When Norton returned to Yale in 1846, his father granted the school $5,000 to create a new School of Applied Chemistry. This eventuated into the Sheffield Scientific School of the University. Norton was made professor, a post he occupied for the few remaining years of his life.

Young Norton was cut down by tuberculosis in 1852. I suspect that he caught the disease from drinking milk from the family cow on his father's farm. It is ironical but fitting to note that, had Norton lived a century later, he would not have died. He would have been cured by streptomycin, an antibiotic discovered by Selman Waksman of the Rutgers Agricultural Experiment Station in New Jersey, a scientific descendant of The Connecticut Agricultural Experiment Station. Waksman, a soil scientist, took the *streptomyces* fungus from the New Jersey soil. His discovery earned him the first Nobel Prize for an agricultural scientist.

Before Norton died, he discovered a kindred soul in Samuel W. Johnson, who carried the torch.

SAMUEL WILLIAM JOHNSON almost single-handedly created the first experiment station in America. Johnson was descended from a long line of colonial ancestors in Connecticut. The earliest was Robert, a founder of New Haven. After the Revolution, Samuel's father, Abner A. Johnson, moved his family from Cheshire, Connecticut, to Kingsboro, New York, in the western foothills of the Adirondacks, where he became a well-to-do merchant and tavernkeeper. Tiring of the mercantile life, he purchased a farm near Lowville, New York, where he became the patriarch of a large family – his own and his relatives.

Samuel William was born in Kingsboro on July 3, 1830. A precocious child, Johnson entered the Lowville Academy at age eleven in the same class with his older brothers and sisters. He learned Greek, Latin, and science – especially chemistry.

He became so enamored with chemistry that D. P. Mayhew, the principal, brought him a copy of Fresenius's book on analytical chemistry from New York City, where it had just been published. That book, now more that one hundred fifty years old and spotted with acid spills, rests in the library of the Station he founded. Samuel's father converted one of his small barns into a laboratory and gave Samuel fifty dollars to buy chemicals. There young Sam prepared most of the pure reagents and worked through the qualitative exercises described in Fresenius's book.

At sixteen he got a job teaching school, but continued his research in his little laboratory. At seventeen, he published "On Fixing Ammonia,"the first in a long string of articles in the *Albany Cultivator*. To show how science could serve agriculture, he wrote:

> When the spirit of enquiry and trust pervades the agricultural community, dissipating prejudice and ignorance, then it may be expected that science will do her perfect work ... and what perfection we may now anticipate from enlightened practice under her auspices.

From a seventeen-year-old in the middle of the last century, both the thought and its formulation were quite remarkable. To put science to work for agriculture! He nailed that thesis to the door of his little private experiment station, and it became the text he would preach for fifty-three years, until he retired in 1900 from his beloved real experiment station.

His options for training in chemistry were very limited, of course, because few colleges taught the subject. After teaching school on Long Island for two years to accumulate funds for further education, he returned to the land of his ancestors in January 1850, and entered the chemical laboratory at Yale made famous by the Sillimans, father and son. He was not yet twenty years old when he began his studies with the two Sillimans and J. P. Norton.

THE PHILOSOPHY OF A YALE SOPHOMORE. As a college sophomore, he proposed in an 1851 *Albany Cultivator* article:

> [that] farmers set up an agricultural institute ... to afford greater facilities for experimental agriculture ... and to provide men and means for striking out into the path of discovery, for increasing as well as diffusing knowledge.... The Institute should possess a legal incorporation ... located near an academy....

It is all there: science should serve society (useful science); find the "path of discovery" (basic science); and increase as well as diffuse knowledge (produce and publish); Johnson recognized the need for applied as well as basic science, and thought scientists should publish their work.

Essentially the same thoughts showed up eighteen years later in the preface to his book, *How Crops Grow:*

> In preparing the ensuing pages the writer has kept his eye fixed steadily upon the practical aspects of the subject.... He would earnestly invite young men ... who are conscious of the power of investigation to enter the fields of agricultural science, now white with the harvest for which the reapers are all too few.... [6]

The essay of Johnson, the Yale sophomore, sets forth many essential features of The Connecticut Agricultural Experiment Station as it exists today, one hundred fifteen years later – a public corporation governed by a board of control, located near an Academy (Yale) but separate from it, devoted to "making a regular business of discovery," and putting the discoveries to work for society.

JOHNSON JOINS THE TREK TO EUROPE. Any scientist hoping to rise in the United States of the nineteenth century had to study in Europe. In 1853 Johnson did just that. His intention of working with the great Liebig was delayed while Liebig built a new laboratory. This was a significant happenstance in the history of the Experiment Station, for it resulted in Johnson's being shunted off to Erdmann's laboratory in Leipzig for a year, where he discovered the *Landwirtschaftliche Versuchsstation* in the suburb of Moechern. To his astonishment and delight, this new research institute matched in most respects the model he had published a year earlier. It was "devoted," Johnson wrote home, "to the advancement of agriculture by scientific investigation carried on in close connection with practical experiment." Here was the marriage of theory with practice – basic and useful science.

The Moechern Institute was only a year old when Johnson discovered it. In 1853 Adolph Stockhardt, an agricultural chemist of Saxony in Germany, heard of J. F. W. Johnston's work in Scotland, but noted that it had failed because the support of farmers had been fickle. Knowing that he needed the permanence of tax support, he organized the farmers to help him, found a wealthy landowner at Moechern to donate the necessary land, and persuaded Saxony's government to charter and support a research agency. He named it the *Landwirtschaftliche Versuchsstation:* literally,the Agricultural Experiment Station – the first in the world.

That it was tax supported deserves special emphasis, for this was a new idea in science. It gave continuity and also converted scientists from amateurs to professionals (e.g. Sir Robert Boyle). Here scientists would earn their own keep from their contributions to society. Scientists would live off science, and not science off scientists. And so it is in America today.

In February 1854, Johnson wrote an article for the *Country Gentleman* about the Moechern experiment station, stating, "If agriculturists would know they must enquire.... When Ag. Societies make Experiment Stations their care and pride, they will more freely and legitimately approach the accomplishment of their end, the perfection of agriculture." It was the first time the term "Experiment Station" was used in America. It is also clear from this that Johnson had not quite yet got the message from Moechern – tax support. He still thought of financial support from agricultural societies.

In 1855 Johnson returned to the United States to become a member of the Yale staff. From his base there, he could carry on his missionary work for the establishment of an experiment station in America. Johnson found the going rough. It was not easy in the eighteen fifties to sell science to society, or "book learning" to farmers and legislators.

He struggled against enormous odds to give life and strength to his proposal to put science to work for agriculture. His salary came from Yale, which was hardly a farm school; even so, he did register some successes, as attested by a three-week course in agriculture in February 1860. A century later, in February 1960, *Scientific American* published this excerpt from its February 1860 issue:

> To see Yale College stepping out from the mists of antiquity and the graves of dead languages, and "taking up the shovel and the hoe" is certainly one of the signs of the times. She made her debut on this new stage the first day of February, having secured the services of 25 leading agriculturists to sustain her in this first effort.

Having more or less convinced Yale College, he then had to convince hard headed farmers and legislators. The persuader was prevention of fertilizer fraud. Johnson was a shrewd tactician. He knew that science would have to do something for society if his idea were not to die. Accordingly, his first effort was taken from the Scotsman, Johnston. He would analyze fertilizer to discourage fraud. By then, farmers knew that plants need fertilizer, but it was difficult to distinguish Quinnipiac River mud from Peruvian guano in a bag labelled *Fertilizer*. Johnson's chemistry could so distinguish.

His first significant success came in 1857 when he was appointed chemist to the Connecticut State Agricultural Society. For them he analyzed fertilizers and fearlessly published the results. This is the first case of consumer protection in America.

THE FOUNDING OF THE LAND GRANT COLLEGES

Then came the Civil War. Congress realized that the war could have been shortened had the North been adequately industrialized. It was impossible, however, to industrialize a country that needed eighty percent of its people to feed itself. The farmer/non-farmer ratio had to shrink. Twenty percent of the population was insufficient for the labor needed by industry. Additional workers might be drawn from the farm, but only if farm efficiency could be vastly improved. Congress moved to solve the problem. It elevated the dignity of agriculture by raising it in the national capital to departmental rank and by creating a brand new system of education in agriculture, known as the Land Grant College System. By legislative act, Yale became the Land Grant College of Connecticut, and Johnson became Professor of Agricultural Chemistry. His reputation rose rapidly. In 1866 Johnson was elected to the National Academy of Sciences when the Academy was only three years old and he was thirty-six. Silliman undoubtedly promoted his election.

Although the Civil War killed the State Agricultural Society, it broke the log jam for tax support for agriculture. Accordingly, after the War, Connecticut set up the State Board of Agriculture as an official state agency, and this Board promptly assigned tax funds for Johnson to continue analyzing fertilizers.

One of Johnson's students in agricultural chemistry was Wilbur O. Atwater. Following the mode of the day, Johnson sent him to Europe. In Germany, Atwater saw and admired the *Landwirtschaftliche Versuchsstation* in Moechern, which by then had spawned many similar institutes in Germany.

THE COMPLETION OF THE GESTATION

The stage was now set for the next act. The Land Grant Colleges had been tax supported for eleven years. Johnson was ready to act. In December 1873, he persuaded the State Board of Agriculture to ask Atwater to discuss his experiences in Europe, especially at the German experiment stations. Atwater seems to have impressed them, for the Board introduced a bill into the legislature in 1874 to set up an agricultural experiment station. Being related to agriculture, the bill was referred to the Committee on Agriculture, where it was voted down. This is perhaps understandable because, in the middle of the last century, farmers were leery of "book larnin'." One farmer who testified before the committee warned:"I tell you go slow. You may be hatching an egg that will cause this state much trouble."

Johnson and Atwater (who was by then professor of chemistry at Wesleyan) redoubled their efforts on behalf of the new Station. Several prominent and wealthy citizens came to their rescue in the legislature of 1875: Theodore S. Gold, MD, who had started the Cream Hill School in Cornwall for farm boys; James J. Webb, a lawyer and farmer of Hamden; and Orange Judd, a book publisher and a trustee of Wesleyan University, who was also a former student of Johnson.

ORANGE JUDD OUTFLANKS JOHNSON

Although the Committee on Agriculture was still uneasy about the idea, Johnson's wealthy friends began to exert their influence. Orange Judd dangled a carrot before the eyes of the Committee. He promised that if the Legislature would appropriate $700 per quarter for two years and assign the new Connecticut Agricultural Experiment Station to Wesleyan University, he would contribute $1,000 of his own money and arrange quarters in the new Orange Judd Hall of Chemistry there.

The Legislature succumbed to Judd's blandishments and passed the bill, which was signed by Governor Ingersoll on July 20, 1875. Atwater, head of chemistry at Wesleyan, became the first director. His first appointees were W. C. Tilden and Walter Balentine, though neither served long in his post. (Balentine subsequently went to Maine as the first Director of that state's Station.)

The second group of appointees were George Warnecke from Germany, Arthur T. Neale, who established the Delaware Station, and Edward. H. Jenkins, who subsequently moved with the Station to New Haven. The new institution began work in October 1875, and promptly began to purchase and analyze fertilizers. Atwater's first report appeared in the 1877 *Proceedings of the State Board of Agriculture.*

A TERRIBLE BLOW TO JOHNSON

After his decades of work, it must have sorely wounded Johnson's pride to see the new Station established at Wesleyan under Atwater rather than at Yale under himself. He must have hidden his feelings remarkably well, however, because the record reveals little of what went on. Jenkins, in his unpublished sketch of the first fifty years of the Station, alluded very obliquely to it.

The new station at Wesleyan incorporated several but not all of the characteristics that Johnson had laid down in his essay. It had Johnson's name. It was set up by the legislature, supported by taxes, and had an advisory committee of farmers. Yet two significant characteristics were missing: it was not a public corporation, and it was *in* an academy, not *near* one.

Johnson and his henchmen must have worked like Trojans during the next two years because the legislature of 1877 passed a new bill, transferring the Station to New Haven, and giving it the charter it needed to fulfill Johnson's specifications. It created a Board of Control with a troika of politicians, academics, and farmers. This guaranteed the fulfillment of Johnson's principle that theory and practice must march together. The legislature specified that the Board of Control consist of the Governor, two members appointed by the Governor, the Commissioner of Agriculture, one member appointed by the State Agricultural Society, one member appointed by the Board of Governors of the Sheffield Scientific School of Yale University, one member appointed by the Board of Trustees of Wesleyan University, and the Director himself.

Most importantly, the bill gave the Station the characteristics of a public corporation. It could own real and personal property. It could sue and be sued "by the name of The Connecticut Agricultural Experiment Station." The legislature further instructed Johnson to convene the first meeting of the Board of Control.

The only person to move from Wesleyan was Edward H. Jenkins, who subsequently became Director. In the fiftieth anniversary report of the Station, Jenkins wrote, "I know that the removal of the station must have been a very bitter disappointment to Prof. Atwater, who won my increased admiration and regard by the way he bore it. Never did I hear from him a single malicious or resentful word about it. Mr. Judd, however, was vociferous in objurgation and threats of destruction. (But for his ungoverned temper, disregard of the opinion and judgment of others, and lack of tact, I incline to think that the station might have remained at Middletown.)"

When the Station moved to New Haven, it had no facilities of its own. Yale very generously offered space in the old "Sheff" building on the corner of College and Grove streets (a space now occupied by Strathcona Hall). It is interesting that Yale seems to have made no move to attach the new Station to the Sheffield Scientific School, especially as it was the Land Grant College of Connecticut at the time.

Yale mothered the new Station until 1881, when the legislature gave it enough funds to buy six acres on Suburban Street, a few blocks north of the Yale campus, and to build its first building. Later, when Suburban Street became surrounded by the city and far from the suburbs, it was renamed Huntington Street. The land was purchased from the estate of Eli Whitney, Jr., whose residence became the office building for the new station. Whitney's old wooden carriage barn was still standing in 1939. It was located just south of the current Jenkins greenhouses.

The 1881 building housed all the chemistry work needed to justify the new station. About the turn of the century, someone etched *Patty W* with hydrofluoric acid on the glass of one of the window panes on the southeast corner of the building. The graffiti is still there, but the building is now the Osborne library.

A SOURCE OF EXPERIMENT STATION DIRECTORS

As the first of its kind, the Station became the place to recruit directors for other new stations being formed. One can find at least five: Armsby to both Wisconsin and Pennsylvania, W. Balentine and C. D. Woods to Maine, W. H. Jordan to Maine and New York State at Geneva, A. T. Neale to Delaware. There are probably others. And Atwater became the first Chief of the Office of Experiment Stations in the USDA.

2

The Soul of the Station

Every institution has a soul, an indescribable essence that gives it dignity, respect, loyalty, satisfaction, and comfort. These qualities derive from the policies and organizational pattern of the institution. What sort of soul; what sort of policy; what sort of organizational pattern did Johnson breathe into his baby?

THEORY AND PRACTICE MUST MARCH TOGETHER

The central theme of The Experiment Station always has been that it do basic research and put it to work for society. The Station serves society by solving problems with plant production, whether in farmers' fields, parks, or people's gardens. Society as a whole pays for it because, without agriculture, society would fall to pieces.

As early as 1855, when Johnson was only twenty-five years old, he wrote home from Liebig's laboratory in Germany that theory and practice must march together. "Rational agriculture is the result of such a union.... Agriculture will flourish from that day when practical men will be philosophical enough to appreciate the philosopher's thoughts and the philosophers practical enough to calculate the farmer's profits." (*Country Gentleman* 5:300-301) Recently, the late de Sola Price, a distinguished historian of science, has written that thermodynamics owes more to the steam engine than the steam engine owes to thermodynamics.

When Johnson became director, he pushed basic research as much as applied. After all, he was elected to the National Academy of Science when he was thirty-six years old. Once he got his fertilizer analyses under way, his next move was to appoint T. B. Osborne to the staff. As we shall see later, Osborne distinguished himself as a basic researcher in biochemistry.

Johnson foresaw or anticipated the controversy over basic and useful science that continues to this day. He encompassed his whole view of this matter in the three words that title his book, *How Crops Grow*. The middle word, *crops*, shows his concern for the food supply of an industrial society. The first and last words reflect his concern for the basic aspects of biology. Overemphasis on the useful would rephrase Johnson's title to *How To Grow Crops*. Johnson sensed that, if scientists knew how crops grow, they could and would provide farmers with the information for growing much better crops so that society would be plentifully fed.

It is not surprising, then, that Atwater, Johnson's student, voiced the same sentiments in his first report of the Station, published in the 1877 document of the State Board of Agriculture. He wrote, "It has been felt from the first that the more abstract scientific

investigations would afford not only the proper, but also the most widely and permanently useful work of an Agricultural Experiment Station." A pragmatist as well, he continued: "There was, however, one subject to take hold of at once and with all our energy – that of commercial fertilisers." The subsequent history of the Station surely proved Atwater right. The discovery of vitamin A from "an abstract scientific investigation" was of more use to society than stopping a few crooks from selling fraudulent fertilizer.

> Such an Institution will be worthy of the name in proportion to its ability to conduct accurate and thorough investigations in agricultural science. [Since] the Station was just beginning its career ... [it] was important to make an impression on the farming public as would lead to its establishment on a firm and liberal basis. There was a bitter need of a better control of the trade in commercial fertilizers in the State.... The demand that the first efforts should be turned in that direction was imperative.

Atwater knew that his basic research could not pay off in time. He had to delay that part of the policy.

The policy has been restated from time to time. In the mid-forties, the then director W. L. Slate contended that the Station must do basic research, but it must also "put a brick into the wall of agriculture." As late as 1978 I paraphrased this in an essay: "My philosophy is to dig new knowledge from the face of the mine and transduce it to fuel to power the society that provides my groceries."

WHAT'S IN A NAME?

The charter names the Station as The Connecticut Agricultural Experiment Station. Shakespeare's Juliet, after asking what's in a name, replies, "That which we call a rose, by any other name would smell as sweet." Maybe so, in the rarefied air of Mr. Shakespeare's poetry, but in the vernacular, "a poker hand is what you call it."

A few years ago, a very thoughtful citizen said that the word *agricultural* in the name of the Station suggests a gravy train for a few farmers. She suggested that the name be changed to "Plant Science Institute," or some variant thereof. The answer, in an editorial, was that an agricultural institute is charged with improving agriculture to serve the Nation and help feed it. Plant science institutes are not.

WHY HAS THE STATION REMAINED SMALL?

The size of the Station has not grown significantly since the 1930's. In a small institution, everybody can speak to every other body about the scientific problems they face. A small outfit does not need departmental budgets to create internal jealousies. By limiting the research to plants and, of course, their enemies, the institution need not grow to encompass agricultural engineering, economics, animal husbandry, etc.

Director Slate always said, "We don't want to be the biggest experiment station in America, only the best." The bigger the Station, the greater the need for bureaucratic organization. "Overorganization of scientists breeds mediocrity, and mediocrity breeds overorganization." Hence, the Station eschews overorganization.

PLANT SCIENCE ONLY

Johnson, being a farm boy, sensed that plants are at the base of agriculture, indeed at the base of society. Without plants, both people and animals die. In his 1869 book, *How Crops Grow*, he dealt only with plants, not with cows, horses, or sheep. Plant scientists can speak synergistically with each other, not very much with animal scientists or economists.

WHY IS THE STATION IN A CITY, NOT ON A FARM?

Numerous visitors to the Station express astonishment at finding an agricultural experiment station in a city. Atwater explained it in 1875. He wrote, "Paradoxical as it may seem, the abstract researches which bring the most practical benefit to farming are made, not on a large scale in the country upon the farms, but in towns where a small number of plants can be experimented with." An additional reason for putting the Station in a city is that the city provides libraries, theaters, transportation, and easy communication.

NEAR TO BUT NOT A PART OF AN ACADEMY

In the 1850's, Johnson wrote that an experiment station should be near to but not a part of an academy. He wanted it to be near an academy so that the two institutions could complement each other's scholarship. The scholarship of Yale has certainly influenced the performance of the Station. Johnson was a young professor at Yale when he propounded his thesis that theory and practice must march together, and it was within the milieu of Yale scholarship that he titled his book *How Crops Grow*. For those who might have entitled it *How To Grow Crops*, very little theory marches with that practice.

As a part of its reciprocation, the Station has hired many graduate students as helpers. Later in this chapter, there is a list of 32 graduate students at Yale and six at other universities who have obtained PhD's while working at the Station. Five of these – Armsby, Jones, Vickery, Mangelsdorf, and Nelson – went on to be elected to the National Academy of Sciences.

WHY THE CORPORATE STATUS?

The most striking difference between the Station and its modern counterparts is that it is a public corporation. It can own real and personal property, can sue and be sued, and can accept endowment funds. It owes this characteristic to Johnson, who wrote in 1851 that a research institute should be organized as a corporation. It is certainly significant that its corporate status has never been tampered with by the legislature.

For example, several years ago, the legislature passed the so-called Sunset Law which specified that every small state agency must undergo an inspection every five years to see if it still performed a useful function. In 1982 the Station was duly examined. The legislature not only confirmed its corporate status, it also broadened the corporate charter and exempted the Station from future periodic examination. Clearly, the legislature approved the performance of its creation, a plant science research agency.

When Johnson's corporation idea got down to the wire, he isolated the Station from the politics of science or society with two clever ideas: (l) the composition of the Board of Control; and (2) the method of appointing the Board. He knew that if the Board were all professionals, the work would be too theoretical, and if it were all farmers, it would be too practical. He fixed the Board so that theory and practice would be enabled to march together. It was composed of scientists, farmers, and laymen.

Service on the Board has surely been a source of satisfaction to its members. Mr. Joseph W. Alsop, farmer, insurance executive, and father of the famed columnist brothers, served 40 years, without pay, of course, even without compensation for travel.

When Chief Justice Raymond Baldwin was Governor, he got acquainted with the Station as a member of the Board. He was so interested that, after he finished his term as Senator, he accepted appointment to the Board by his alma mater, Wesleyan University, and served until he became Chief Justice.

WHY NOT AN EDUCATIONAL INSTITUTION?

Most University professors think that the Experiment Station is an oddball because it is an independent entity, not attached to a university. One day a few years ago, a distinguished professor of science in a major university and a friend of mine inquired about the Station's policies on basic research. He was mailed a ream of data. He replied: "After looking over your list of [National] Academy members and the contributors to your book on *How Crops Grow a Century Later,*[7] and meditating on the history of The Connecticut

Agricultural Experiment Station, I have decided that the quality of people will overcome any deficiencies of organization." (*Translation*: "I can't see how you attained such distinction outside a university!") I wonder how he accounts for the Nobel Prizes won by scientists at the research laboratories of the Bell Telephone and General Electric Companies. They have no university connections.

Mr. Professor, it is striking indeed that none of the four earliest experiment stations in the world – Professor J. F. W. Johnston's outfit in Scotland, the Rothamsted Experimental Station in England, the Moechern *Landwirtschaftliche Versuchsstation* in Germany, and The Connecticut Agricultural Experiment Station in the U.S. – was part of an educational matrix. In 1843 J. F. W. Johnston wrote that the role of the college is to teach and he contended strongly that research must be kept separate from teaching. And, as we have seen, S. W. Johnson, J. F. W. Johnston's scientific "grandson," also insisted on separating research from teaching. His dictum has been followed ever since.

It is also interesting that the Connecticut Legislature put the Station in a university at first, but then, after two years, took it away and made it into a public corporation. Legislators don't equate research with teaching.

USING GRADUATE STUDENTS AS ASSISTANTS

Any trade or profession must arrange for the training of its apprentices or it will dry up. The Experiment Station has done just that. Johnson began by hiring two graduate students, E. H. Jenkins and H. P. Armsby, to do the analytical work on fertilizers. In addition the Station has hired as technicians at least thirty-two other students from various universities, as shown in the following table.

Graduate Students Supported
As Technicians in the Experiment Station

Student	Year of PhD	University	Field
E. H. Jenkins	1879	Yale	Chemistry
H. P. Armsby	1879	Yale	Chemistry
W. E. Britton	1903	Yale	Botany
A. L. Winton	1905	Yale	Chemistry
D. F. Jones	1916	Harvard	Genetics
W. R. Hunt	1921	Yale	Botany
H. B. Vickery	1923	Yale	Chemistry
P. C. Mangelsdorf	1925	Harvard	Genetics
W. F. Morgan	1925	Ohio State	Soils
G. L. Zundel	1927	Yale	Botany
H. P. Bender	1927	Yale	Botany
R. B. Friend	1927	Yale	Entomology
H. J. Lutz	1929	Yale	Forestry
R. L. Beard	1939	Yale	Entomology
L. C. Curtis	1940	Cornell	Genetics
L. Roberts	1942	Yale	Genetics
G. A. Plumb	1946	Yale	Entomology
O. E. Nelson	1947	Yale	Genetics
N. Nienstadt	1948	Yale	Genetics
N. Poletica	1948	Yale	Forestry
N. Everett	1949	Yale	Genetics
W. Gabelman	1949	Yale	Genetics
A. N. Meiss	1950	Yale	Chemistry
E. Peterson	1950	Yale	Genetics
L. P. Krier	1951	Yale	Forestry
J. Buchert	1951	Yale	Genetics
A. Munson	1953	Yale	Genetics
W. L. Galinat	1953	U. Wisc.	Genetics
R. Benoit	1954	Yale	Botany
B. Parker	1956	Yale	Botany
D. Leonard	1957	U. Conn	Entomology
R. A. Jaynes	1961	Yale	Genetics
G. Stevens	1961	Yale	Forestry
C. Bingham	1964	Yale	Ecology

3

Organizational Changes

As time passed the Station changed. This chapter describes some of these changes as the years have moved down through the century from 1875, when Atwater and Johnson set it up, to 1975, when the Station was one hundred years old.

1875. Chapter 1 shows the historical markers up to July 20, 1875, when Governor Ingersoll signed the bill that became the first historical marker for this chapter. In part this bill read: "for the purpose of promoting agriculture by scientific investigation and experiment, there is hereby established an institution to be called and known as *The Connecticut Agricultural Experiment Station.*"

In October of that year, W. O. Atwater opened the Station in Orange Judd Hall at Wesleyan University in Middletown. The new staff set out immediately to analyze fertilizer to prevent fraud.

1877. The General Assembly moved the Station to New Haven, where it was housed in the "Old Sheff" Hall in Yale University. Because Johnson's books were in the Experiment Station office, they were frequently consulted by the Station staff, who were scientific neighbors of Willard Gibbs of thermodynamics fame. In his Fiftieth Anniversary Report, Jenkins speaks of Gibbs: "I particularly remember finding an unknown visitor perched on a step ladder consulting Liebig's *Annalen*; a quiet figure, with a pleasant smile and a gentle voice, suggesting shyness and refinement, who explained that his name was Gibbs and that Professor Johnson had given him permission to consult some of his books. The name meant nothing to me then and I went on. The fact that he was Professor Willard Gibbs, the great authority on mathematical physics whose work would later mark an epoch in the method of physical chemistry was, of course, unknown to me. Very likely at that time he was working on the two famous papers which appeared a year or two later in the Proceedings of the Connecticut Academy."

1881. Yale asked the Station to move, as the University needed the space.

1882. The Station bought (from the estate of Eli Whitney Jr.) "about 5 acres of land situated on Suburban St., nearly one mile and five eighths air line from city hall in New Haven, having on it a commodious dwelling, a house, a barn, and a well." (The well, now covered over, is located opposite what is now the northwestern entrance to Slate Laboratory.) The report for 1882 goes on to say: "A substantial brick building has been erected for a chemical laboratory." (Slate always contended that this building is probably the first ever erected specifically for an experiment station). "The

original property cost $12,000 and $8,809.04 has thus far been paid out. The Station occupied the new quarters on Sept. 1, 1881." The report contains another interesting remark: "The Station grounds ... may be reached by the Whitney Avenue Horse Cars which leave the corner of Chapel and Church Sts. every hour and half hour." This year had also the first listing of the Station in the telephone directory. (The first telephone exchange in America was established in New Haven in 1878.) Director Johnson's residence on Trumbull Street is also listed. The report for 1882 says "The Station has telephone connection and may be spoken from the Central Telephone Office, 346 State Street or from Peck and Bishop's office in Union R.R. Depot."

1883. Jenkins was appointed Vice-Director.

1886. Station moved into basic research. Johnson hired Osborne, who, by the way, was his son-in-law. History proves that this bit of nepotism was eminently justified: Osborne established what was to become the department of Biochemistry, the second department.

1887. Congress passed the Hatch Act, appropriating $15,000 to establish an experiment station in each State. The recipient institution in each state was to be decided by the local legislature. Senator Hawley (Director Jenkins's brother-in-law), saw to it that the Station shared the funds equally with the agricultural college at Storrs. An interesting point: the Hatch Act was put together by the presidents of the Land Grant Colleges, and Yale, not Storrs, was still Connecticut's Land Grant College. Apparently, the State Grange induced the Legislature to accept its view, despite Yale's objections.

1888. Roland Thaxter, first appointee under the Hatch Act, set up the third department in the Station and called it Mycology.

1890. The Station began field research on the Hamden farm of Board Member J. H. Webb (The area is now called Spring Glen.)

1894. W. H. Britton arrived as a botanist. He later became State Entomologist and set up the fourth department, Entomology. The first greenhouse was built this year.

1896. The Lockwood endowment received.

1900. First tobacco shade tent erected. Johnson retired. Jenkins promoted from Vice-Director to Director. The 1900 Report reads: "In November 1900, The Association of American Agricultural Colleges and Experiment Stations held its meetings in New Haven and Middletown. The occasion was notable because it marked the twenty fifth anniversary of the establishment of the first agricultural station in the United States, which began work in Middletown in 1875." The same report gives data also on Mr. Lockwood, as follows: "Mr. Lockwood had been interested in this Station and its work from the very inception.... [He] was a frequent attendant at the annual conventions held by the State Board of Agriculture.... The Station was the first of its kind in the country to be established by any state as Mr. Lockwood knew, and now he comes forward as the first person in America to bequeath a sum of money as an endowment."

1901. Walter Mulford arrived to set up the Department of Forestry, the fifth in the Station.

1905. E. M. East arrived from Illinois to set up a sixth department, Agronomy, which later became Department of Genetics. East started on the road to hybrid corn, to be discussed in a later chapter.

1909. The Founder, S. W. Johnson, died. Herewith an excerpt from the minutes of the Board of Control:

> In 1869 he published *How Crops Grow*, a book that has been more widely read and studied than any other work on agricultural chemistry which was ever used. It was reprinted in England, translated into German, Russian, Swedish, Italian, and Japanese. He secured for Connecticut, with the aid of others, who were taught by him, the honor of inaugurating in this country the work of the agricultural experiment stations which are now in successful operation in every state in the Union.

Copies of these translations are in the Station library. A second experimental field was rented in Centerville for East's expanding research on breeding corn and tobacco. The Station, to show farmers that it could do field research as well as laboratory research, held a summer field day on the new field. The 1909 report contains a picture of farmers and their wives on the new fields. The General Assembly appropriated $30,000 to build a fireproof addition to the chemical laboratory. Construction began in October.

1910. "On the morning of Jan. 10, 1910, a fire, believed to be of incendiary origin, burned out the [old] building to which the new structure was an addition." The building was rebuilt and named Johnson Laboratory.

1911. Needing more land, the Station used Lockwood money to buy twenty acres with a small house for the farm superintendent in Mt. Carmel. Immediately, a small apple and peach orchard was set out.

1912. The 1881 building, vacated by the chemists, was converted into a library. Some uneasiness about two Agricultural Experiment Stations in Connecticut becomes apparent. Acting together, the Board of Control at New Haven and the Board of Trustees at Storrs appointed Jenkins as Director of both Stations. There seems to have been a sort of "gentleman's agreement" that two stations would operate in Connecticut with New Haven working in plant science and the Storrs Station concerning itself with the rest of agriculture.

1916. First automobile was purchased.

1919. The Tree Protection Examining Board was established by the legislature to combat fraud in the "tree expert" business. It helped to assure that a "tree expert" was in fact a tree expert. Britton, Clinton, and Filley constituted the first board.

1921. Tobacco Substation established as the seventh department. G. H. Chapman made Director.

1922. W. L. Slate, Jr. came from Storrs as Vice-director.

1923. Jenkins retired. Slate promoted to Director of both stations. Department of Soils established with M. F. Morgan as head.

1925. The Station celebrated its semicentennial. P. J. Anderson was made head of the Tobacco Substation.

1931. Jenkins died.

1932. Jenkins laboratory constructed. Plant Breeding Department renamed Genetics.

1934. Departments of Botany, Entomology, Forestry, and Genetics moved from Johnson Chemistry building to new Jenkins building.

1937. Clinton died. E. M. Stoddard named acting chief of Botany.

1939. Britton died. R. B. Friend named head of Entomology. Botany department renamed Plant Pathology and Botany. J. G. Horsfall appointed as chief.

1940. C. I. Bliss arrived to become Station Statistician. He became a great asset in the design of experiments.

1944. Morgan killed in the Philippines. Lunt made acting head.

1946. H. W. Hicock replaced W. O. Filley as chief of the Forestry Department. Slate suffered from ill health.

1947. Friend, also in ill health, requested relief from the Vice-Directorship. On July 1, Horsfall was made Vice-Director. The first issue of *Frontiers of Plant Science* was published. Jorgensen, President of the University of Connecticut, tried to move Station to Storrs, but the Governor refused.

1948. On January 1, Horsfall was promoted to Director. The General Assembly abandoned printed annual reports; the Station instituted its own annual report.

1950. Seventy-fifth Anniversary celebration. The Connecticut Development Commission awarded the Station a bronze plaque on a boulder saying that the Station was the first in America. Cliff Hardin of Michigan, later Secretary of Agriculture, came to the celebration. The featured speaker at the banquet was Detlev Bronk, President of the National Academy of Sciences. The Lockwood series of lectures was initiated.

1953. An important milepost was reached when H. B. Vickery obtained the first grant to an Experiment Station from the National

Science Foundation. R. B. Friend retired and Neely Turner was promoted to chief of Entomology and Vice-Director. P. J. Anderson retired as head of the Tobacco Substation and was replaced by Gordon Taylor, who was given the title of Assistant to the Director.

1954. The first scrolls for twenty-five years of service were awarded. Louise M. Brautlecht left a small legacy, which was used to purchase a copy of the *Encyclopedia Britannica*. The name of the Tobacco Substation was changed to Tobacco Laboratory.

1955. The fortieth anniversary of Jones's arrival at the Station. Eight hundred guests convened at Field Day that summer to hear former Vice President H. A. Wallace tell that, having heard of Jones's work on hybrid corn, he promptly came to New Haven to talk about it with Jones, then went home to Iowa to establish The Pioneer Hibred Seed Corn Company, which first made successful commercial use of Jones's invention. P. E. Waggoner was installed head of a new Department of Climatology, the second in the country.

1956. The Osborne Library was modernized. The dedication speaker was E. V. McCollum, Osborne's competitor for the honor of discovering vitamins.

1957. The Department of Climatology's name was changed to Soils and Climatology. The Feds came to Connecticut and demanded the authority to spray the whole State with DDT to "eradicate" the gypsy moth. Knowing eradication was impossible and not wanting the DDT contamination, the Director and the State Entomologist recommended that the Board of Control refuse permission. A newspaper, the *Hartford Courant,* hearing of the refusal, wrote in an editorial: "If necessary, let us call out both the [Governor's] Foot Guard and the Horse Guard to repel further forays by Federal Authority, even if it comes armed with DDT." It is worth noting that 1957 was five years before Rachel Carson published her book, *Silent Spring*, excoriating entomologists for using pesticides.[8]

***Circa* 1958.** Jones and Mangelsdorf, with the assistance of the Research Corporation, applied for a patent on the use of the "restorer gene" in plant breeding. Jones insisted that the patent would force his fancied midwestern detractors to give him his due.

1959. The Board of Control awarded a diamond pin to Owen Nolan as the first staff member to have served fifty years. Slate Laboratory built on the site of the former Whitney Residence. Thaxter Laboratory was pulled down and the fireplace mantles transferred to the Slate Laboratory. One was put into the Director's office; the other, into the Board Room across the hall. H. W. Hicock retired. Forestry was moved into the Department of Soils and Climatology.

1960. D. F. Jones retired from the Genetics Department. Upon

retirement, Jones was asked to tell his hybrid corn story at the summer Field Day. When he sat down, he received the only standing ovation ever given a Field Day speaker. His speech was recorded on tape. Harry Stinson was promoted to head of the Department of Genetics. E. M. Stoddard followed Nolan as a fifty-year veteran, and the Board of Control presented him also with a diamond pin. No one since has served for fifty years, although we must not forget that Jenkins served forty-eight years.

1962. The Department of Plant Pathology and Botany celebrated its Diamond Jubilee with a symposium on *Biochemical Plant Pathology*. Stinson moved to Cornell from the Genetics Department.

1964. Peter Day was appointed head of the Genetics Department.

1965. At the suggestion of Congresswoman Ella Grasso, the Station was given a bronze plaque making it a National Historic Landmark. The plaque is attached to a boulder in front of Slate Laboratory.

1967. H. B. Vickery retired from Biochemistry. He was replaced by I. Zelitch. H. J. Fisher retired as head of Analytical Chemistry. He was replaced by Gordon Hanna.

1968. Johnson Chemistry Laboratory rebuilt and modernized.

1969. Neely Turner retired. P. E. Waggoner was made Vice-Director. J. F. Anderson made head of the Entomology Department.

1970. The Station reached another significant milepost. After a long fight, the Research Corporation finally obtained approval of the Jones and Mangelsdorf patent and the corn companies finally paid off. Using some of the funds, the Board of Control established the Jones Gold Medal Lectureship and modernized the auditorium in the Britton Building as the Jones Auditorium. The Board of Control established THE S. W. JOHNSON DISTINGUISHED SCIENTIST AWARD for staff members. Dimond, Horsfall, and Vickery became the first to receive the award. A new department of Soil and Water was established, with C. R. Frink as head.

1971. On December 31, J. G. Horsfall relinquished the Directorship to P. E. Waggoner and returned to full-time research. A. E. Dimond was made Vice-Director, but died of pancreatic cancer in February. A new Department of Ecology and Climatology was established with Donald Aylor as head.

1972. C. R. Frink was made Vice-Director. Due to the catastrophic effect of "homogenized tobacco" on tobacco farming in the valley, the name of Windsor laboratory was changed to "The Valley Laboratory," which celebrated its fiftieth year in November.

1975. Horsfall retired and became a Scientist *emeritus*. The Station reached its Centennial and, with this event, the story comes to an end.

4

Contributions

Johnson's dictum that theory and practice must march together is mentioned in several places in this book. The question is, "March to where?" This chapter lists the discoveries scientists have made as they marched along Johnson's road toward help for humanity.

In 1927, shortly after the fiftieth anniversary of the Station, Director Slate published the following list of its contributions: discovery of the cause of potato scab (1889); introduction of spraying to control plant pests (1891); fermentation of tobacco in bulk (1895); the introduction of shade tents for growing tobacco (1900); the study of proteins, which led to the discovery of vitamins (1910); a new method of breeding corn, which has completely changed the methods of improving this cereal (1917).

Slate failed to mention the discovery by Osborne and Mendel of the importance of amino acids in the animal diet, published in their 1918 watershed paper, "Growing Chickens In Confinement."[9] Their study had probably not yet proved its significance in 1927, although Slate recognized it in his report for 1940:

> Research into the fundamental principles that control the behavior of living things, whether plants or animals, has contributed more than any other factor to this transformation [of agriculture]. However, such research is frequently of a nature that seems far removed from the growing of crops and the care of animals. Nevertheless, the information gathered ... leads finally to an enlarged understanding of nature without which progress would be impossible.
>
> Thus, when Osborne and Mendel, in 1918, showed that chickens can be raised in cages on artificial diets, no commercial application of their procedure could have been foreseen. They were not in a poultry department trying to reduce the cost of chicken meat or eggs. Their objective was to see if a bird responds to vitamins the same as a rat. Previously, exercise in the open air, contact with the ground, and a supply of green food were regarded as essential for the growth of chickens to maturity. Their experiments proved that successful growth could be obtained by purified experimental diets, provided proper vitamins especially vitamin D were made available. Chickens are now raised that have never seen the light of the sun, nor have scratched in the barnyard. By now the use of cod-liver oil has become commonplace. This contribution to the poultry industry was an outgrowth of fundamental research.

AN UPDATED LIST OF CONTRIBUTIONS

The following updated list of the contributions of the Station has been made in consultation with various staff members, who

generated a list of contributions that are here split into three categories: (a) contributions to practice, (b) contributions to human health and human welfare, and (c) contributions to theory. These lists were then submitted to Director Anderson, to Vice-Director Frink, to Director *emeritus* Waggoner, to Vice-Director *emeritus* Turner, and to department heads Aylor, Hankin, Magnarelli, Stephens, and Zelitch, who were asked to select the ten major contributions in each category and rank them in order. As not everyone ranked them in exactly the same order, they are ranked here in order of the number of votes for each.

RANKED CONTRIBUTIONS TO PRACTICE

1. 1917. Jones flew in the face of dogma and crossed two crosses to make the production of hybrid corn workable. The report for 1963 says that hybrid corn has resulted in a net increase in wealth in the U.S. of 904 million dollars – ten percent of that year's national budget.

2. 1918. Osborne and Mendel published their watershed paper "Growing Chickens in Confinement."

3. 1940. Horsfall discovered the fungitoxicity of bisdithiocarbamates.

4. 1934. Morgan published his "quick test" for soil fertility.

5. 1914. Jones and Mangelsdorf discovered a "restorer gene" to make cytoplasmic pollen sterile corn practicable.

6. 1926. The Station introduced the first crossed sweet corn variety.

7. 1853. By analyzing fertilizer to prevent fraud and then publishing the results, Johnson invented the principle of consumer protection.

8. 1945. Roberts and Nelson discovered that the Connecticut inbred corn (C-103) contains a gene which makes it highly resistant to root rot. Most of the world's corn hybrids are now resistant to the disease because they carry the C-103 gene. In the 'fifties, two Spanish corn breeders worked at the Station with Jones to incorporate C-103 into one of their hybrids to create one whose ear was fed to animals, and whose stalk was used to extract sugar.

9. 1900. Jenkins and Sturgis introduced the shade tent for Connecticut tobacco.

10. 1889. Thaxter introduced the first soil fungicide in America, potassium sulfide, for onion smut.

UNRANKED CONTRIBUTIONS TO PRACTICE

1877. Investigation of seeds was undertaken by Messrs Warnecke and Jenkins in accordance with the methods employed in Germany, which these gentlemen had the opportunity to study with Dr. Nobbe at the German Experiment Station in Tarrand.

1889. Thaxter named the fungus causing downy mildew of lima beans.

1890. Thaxter constructed a home-made sprayer, probably the second one in America.

1890. Thaxter helped to pioneer Bordeaux Mixture in America.

1892. In order to control "pole rot" of tobacco, Sturgis redesigned the tobacco curing barn with vertical side ventilators, one for each row of tobacco. This type of barn is still in use today.

1893. Sturgis issued probably the first spray calendar for America.

1899. Whitney initiated soil survey in the United States.

1913. Stoddard and Clinton probably observed hypovirulence in chestnut blight but did not recognize it.

1919. Wildfire disease of tobacco invaded Connecticut and stimulated the establishment of the Tobacco Laboratory. The disease faded out after a few years.

1921. Garman discovered the effectiveness of spray oil to control red mite.

1927. Hicock and P. Anderson, when introducing creosote to prevent decay of tobacco tent poles, wrote: "Within a comparatively few years chestnut for poles will be exhausted." [An elegant prediction].

1930. Turner discovered the effectiveness of mineral seal oil as an insecticide.

1933. X-disease of peach discovered by Stoddard.

1934. The Plant Disease Handbook published. This became a very popular publication.

1937. The downy mildew of tobacco invaded Connecticut. Anderson showed that benzene vapor would control it in the seed bed.

1940. Hicock and Olson developed the charcoal kiln to provide wartime fuel and to provide income from second growth forests.

1946. Johnson found that sulfathiazole can control foul-brood disease of honey bees.

1946. DDT and Dithane eliminated the need to use the injurious Bordeaux mixture. As a result, potato yields were increased by one hundred to two hundred bushels per acre.

1946. Lunt demonstrated the usefulness of sewage sludge for soil improvement.

1948. Charcoal used to inactivate benzene hexachloride in potato soil. To combat wireworm, potato farmers had spread BHC over a thousand acres in 1947. In 1948, potatoes from that land were inedible. At a conference, someone made the improbable suggestion to adsorb it on activated carbon. To everyone's astonishment it worked.

1947. P. V. Anderson reported that the brown root rot disease of tobacco is caused by the root lesion nematode. Swanback showed that copper is essential for quality of tobacco, and growers now add copper to their fertilizer formulas.

1948. Benoit showed that the algae in Lake Zoar thrived on phosphorus from the hat factories upstream in Danbury.

1949. Rich and Horsfall published Karathane, a new powdery mildew fungicide.

1951. Lounsbury discovered the tobacco cyst nematode.

1951. Blue mold of tobacco reappeared. P. V. Anderson showed that the dithiocarbamates will control it. Anderson and Swanback substituted gas for charcoal in the tobacco curing barn.

1951. Lunt showed that waste wood chips can improve soil structure.

1954. Dimond used lime-sulfur to stop damage to greenhouse roses from mercury paint. The grower thought this was a miracle.

1957. Taylor and Rich published the prescient remark that "Increased knowledge of the [new] fleck disease had led to an hypothesis of water congestion and air pollution interaction."

1959. New resistant variety of lima bean was named Thaxter by USDA.

1960. Rich discovered first chemical control of ozone damage, spray with a dithiocarbamate fungicide.

1961. Sand found fleck-resistant strains in tobacco. The report says that the "genes have saved the industry from disaster."

1963. In *Plants, Shade, and Shelter,* Waggoner showed how trees, thickets, parking lots and beaches affect human behavior.

1966. Peaslee confirmed the fatal effect of salt on roadside trees.

1968. Procopy found that colored spheres hung in apple trees will attract apple maggot flies.

1969. Sawhney and Zelitch determined the role of potassium in guard cells; their paper became a "Citation Classic."

1970. Hill published a survey of coastal wetlands.

1972. Hill showed that salt marsh soils are high in sulfur. When they dry, their pH drops dramatically, causing metal to corrode and limiting the growth of vegetation on dredged material deposited on land.

1972. Taylor discovered the invasion of another new Southern disease of tobacco, black shank. Soil fumigation and resistance saved the crop.

1973. Day and Anagnostakis demonstrated that European hypovirulence could control chestnut blight in American chestnut trees.

1973. DeRoo developed an artificial soil composed of sand, peat, and vermiculite for nurserymen who must sell soil with potted plants.

RANKED CONTRIBUTIONS TO MEDICINE AND HUMAN WELFARE

It is astonishing to see how much a plant-science institution like the Station can contribute directly to human welfare. It seems worthwhile to set these contributions down in a separate section.

1. **1903.** Observations of mosquitoes in the State began, with a view toward lessening this nuisance. The 1937 report says that by then 12,000 acres, or about half of the salt marshes of the State, had been drained.

2. **1895.** Legislature passed the food control act. Jenkins wrote: "I believe that this is the first experiment station which has been committed by state law to the work of examining food products."

3. 1904. Wells, of the University of Chicago Medical School, worked with Osborne to explain the nature of anaphylactic shock. In the ensuing years, Wells and Osborne published six papers together on the subject.

4. 1908. The drug act was passed. By 1912 heroin had become a new threat to society. The Station was often called upon by the police to identify suspected illicit drugs.

5. 1910. Osborne and Mendel discovered the essentiality of amino acids in an animal's diet. This is discussed in detail in the chapters on genetics and biochemistry in *The Saga of Corn*.

6. 1913. Osborne and Mendel published on vitamin A. This, too, will be discussed more in subsequent chapters.

7. 1944. Zentmyer reported the biological significance of chelation. Later, it would be used for removing plutonium from children.

8. 1943. Vickery took his knowledge of the organic chemistry of proteins to Harvard to help develop synthetic blood plasma for wartime.

9. 1957. Hill showed the relation of soil type to efficiency of septic tanks.

10. 1970. Hankin and Hanson developed a rapid method for testing lead in the urine of children suspected of eating lead paint. The city of Hartford sent them a letter of congratulations for this contribution to solving a cause of mental retardation.

UNRANKED CONTRIBUTIONS TO MEDICINE AND HUMAN WELFARE

1959. Secretary Fleming banned sale of cranberries on account of aminotriazole. After sixteen days of round-the-clock research, Kierstead and McLean developed a workable analytical method for measuring it. The cranberries were saved.

1967. Hill applied the percolation theory to septic tank drainage.

***Circa* 1967.** When "diet colas" appeared, the purveyors added glycine to mask the flavor of saccharine. Hanna and Coppola devised a method to measure the glycine.

1963. Hankin and Wickroski devised a method for measuring lactose in hot dogs and bologna.

1964. Coppola and Wickroski devised a way to measure sodium nitrite, a preservative for "corned beef" thought by some to be a carcinogen.

1970. John Anderson showed that flooding controls the salt marsh deer fly, a major biting fly in Connecticut.

1972. Sawhney and Hill showed that acid soil types recover adsorption capacity for septic tanks more rapidly than neutral soils.

1974. Fermentation residues of the Pfizer Company showed no harmful effects on corn.

1974. Hill and Frink related the longevity of septic systems to soil type.

RANKED CONTRIBUTIONS TO THEORY

1. 1904. Clinton discovered the oospores of *Phytophthora infestans*.

2. 1944. Zentmyer showed that 8-quinolinol kills spores by robbing them of metal by chelation. Albert of Australia tried hard to displace Zentmeyer's priority but failed by a few months.

3. 1934. Morgan split open the century-old problem of soil analysis as a means for measuring soil fertility by extracting soil, not with a strong acid, but with an imitation of the root excretion. He used a sodium acetate-acetic acid buffer he called the "Universal Soil Extractant."

4. 1902. Osborne studied the competitive influence of nucleic acids on the analysis of proteins. A half century later, nucleic acids showed up as building blocks for DNA.

5. 1890. Thaxter proved the etiology of potato scab using a marvelous experimental design. He scrabbled the soil away from a young tuber, inscribed his monogram, RT, on it with a nail, and plastered the wound with an agar culture of the suspected fungus. At maturity the tuber exhibited his monogram in scab.

6. 1959(?) Zelitch discovered the role of glycolic acid in the operation of stomata. Working with glycolic acid, he discovered the photorespiration principle – that some plants produce CO_2 even while consuming it.

7. 1964. Kring, noticing that aphids fly away from the sun, protected plants from aphid attack by putting a reflecting aluminum sheet over the soil beneath the plants.

8. 1967. Frink, in a landmark paper entitled "A Nutrient Budget," rationally analyzed eutrophication of a Connecticut lake.

9. 1965. Waggoner showed how stomates affect the hydrology of crops and forests.

10. 1969. Waggoner wrote the first computer program for an epidemic of plant disease.

UNRANKED CONTRIBUTIONS TO THEORY

1898. Sturgis published on the "calico disease" (mosaic) of tobacco, the first paper on a plant virus disease published in America.

1923. Clinton wrote of mosaic: "We believe that we know as much about this disease as any one, but the cause still remains a mystery."

1924. Morgan first to use aerial photographs to map soils.

1926. Morgan showed the relation of soil pH to black root rot in tobacco.

1926. Clinton wrote again: "A most interesting discovery at the Station this year is that tobacco leaves dried and preserved for 24 years still carry the active principle [of mosaic] and can be used to infect growing plants." (Clinton, a mycologist at heart, could not possibly bring himself to think this was evidence that the "active principle" was a chemical, not an organism.)

1930. Vickery showed that tobacco seed contains no nicotine.

1933. Morgan introduced his "universal soil extracting solution."

1935. Vickery elucidated the role of organic acids in curing tobacco.

1935. Pucher and Vickery developed a method of determining glutamine and asparagine that has been widely used in biochemistry.

1935. Friend described the ecology of the spruce gall aphid.

1939. Beard showed that the fly parasite of the squash bug could not be of economic importance as it does not kill the squash bug until after it has quit feeding.

1942. Turner and Horsfall first to demonstrate that Bordeaux mixture does not "stimulate" potatoes, but actually dwarfs them. The apparent stimulating effect is due to insect control.

1942. Pucher and Vickery identified "crassulacean malic acid" as isocitric acid. This discovery helped clarify the citric acid cycle.

1943. Turner showed: (a) that corn borers cannot survive on corn plants before tassels are formed; and (b) that corn borers invade the ear directly and do not migrate from elsewhere on the stalk.

1943. Analysis by Jacobson of earthworm castings was pioneer research on the performance of earthworms in the soil.

1944. Horsfall and Dimond showed that low sugars in plants increase damage from tomato blight, chestnut blight, and corn borer.

1949. Turner discovered synergism between nicotine and pyrethrum.

1952. Beard showed the physiological effects of predator venoms on insects.

1955. Palmer cut the drudgery from the analysis of organic acids by using ion-exchange chromatography.

1955. Wallis found that equine encephalitis in pheasants is spread by pecking.

1956. Waggoner, *et al.*, initiated watershed research on the physics and meteorology of the aerial dispersal of fungus spores, using the blue mold fungus of tobacco.

1956. Garman showed that Baldwin spot of apples is due to calcium deficiency.

1956. Tamura discovered aluminum interlayers in Connecticut soils, known at that time in only two other locations in the world.

1957. DeRoo published a new method for studying root distribution in soil, based on experiments using tobacco.

1958. Greenwood showed that: (a) larvae of the eastern field wireworm on potato must have some animal food to survive; (b) females lay their eggs only in easily excavated sandy soils; and (c) parasitic bacteria help to regulate the population.

1958. Plumb demonstrated that the salivary secretion of the spruce gall aphid initiates the formation of the galls.

1958. Wallis showed that gypsy moth larvae are stimulated to migrate by the factors involved in the maturation of foliage. He showed also that gypsy moth larvae eat more foliage in dry seasons than in wet seasons because they need more water.

1958. Turner found that inbreeding milkweed bugs causes a sharp reduction in egg production. Crossing two inbred lines sharply increases egg production. He suggested that outbreeding might cause outbreaks of insects.

1962. Frink published a new theory on solubility of aluminum hydroxide.

1964-1979. Waggoner's experiments in forests showed that modifying stomatal opening can change the hydrologic cycle and conserve soil water.

1966. Hanson introduced a new concept, prochirality, and invented a system to describe the biochemistry of enzymatic reactions. This is widely used in biochemistry research.

1967. Forty years after Hicock established his forest transects in 1927, Stephens found extensive changes in tree growth and distribution.

1968. Waggoner made a computer simulation of the microclimate in a forest and showed the impact of leaf area and stomata upon temperature and evaporation in the canopy.

1969. Plant pathologists discovered that leaves scrub pollutants from the air, and that the contribution of forests to atmospheric cleansing can be calculated.

1971. Day introduced to America the idea of hypovirulence in chestnut blight.

1971. Hill and Parlange showed that the advancing front of water percolation is stable in uniform soil, but finger-like in a layered soil.

1972. John Anderson discovered a parasitic wasp that controls the elm span worm.

1973. Poincelot isolated the membranes surrounding chloroplasts and was the first to identify their lipid constituents.

1974. Lime enables soils to regenerate phosphorus sorption sites.

1974. Stephens related tree mortality to insect defoliation.

5

Analytical Chemistry

Analytical Chemistry started the Station off and provided much of the stimulus to keep it alive for these many years. This account runs from 1853 until the centennial in 1975. Analytical Chemistry initiated in America the idea of consumer protection.

BEFORE THE STATION WAS ESTABLISHED

The consumer protection idea goes back to 1853 when Samuel W. Johnson, then a student at Yale, published an article in the *Connecticut Homestead*. The title was "Superphosphate of Lime," an account of the result of analyses he had made on two samples of artificial fertilizer offered for sale; without doubt, the first paper in America on consumer protection, without doubt the first use of analytical chemistry to detect fraud in consumer goods.

In January 1857, Johnson delivered an invited address entitled "Frauds in Commercial Manures" before the State Agricultural Society. This has been referred to as the commencement of the agricultural experiment Station movement in America. Among other things, Johnson said:

> Almost within 15 years a new and extensive business has sprung up ... concentrated and costly fertilizers.... It is your duty and for your interest, you farmers of Connecticut, to see that there be not too many 'tricks of the trade' introduced into this new business.... There is but one way by which we can protect ourselves ... it is the resources of the science of chemistry ... which alone can reveal frauds which may creep into their preparation.... The plan is one adapted to be carried out by your society and is as follows. Let a trustworthy chemist be employed to analyze every year all the various manures that come into the Connecticut market.... The results should be published in the organ of the Society.

Johnson was a superb salesman. At that meeting in 1857, he was elected chemist of the State Agricultural Society, which allocated to him some funds for the work.

The Civil War killed the State Agricultural Society and its $400 payment to Johnson's laboratory for fertilizer analysis. After the war, in 1866, the Connecticut State Board of Agriculture was established. It renewed the arrangement with Johnson, and he made his first report to the new Board in 1869. The actual analytical work reported there was done by W. O. Atwater, one of Johnson's students, who later became first Director of the new Experiment Station in Middletown.

The report attracted attention outside Connecticut. The Commissioner of Agriculture in Washington wrote that he understood Johnson had analyzed numerous samples of fertilizer, and continued: "I would be glad to have you furnish in some detail the result of the investigation for the use of the Department." From Rutgers College, Dr. George H. Cook wrote: "Your straightforward estimate of the value of different fertilizers is producing a sensation among both manufacturers and consumers, and will be of great service to agriculture."

At this point Johnson turned over to others all of the actual analytical work. He wrote his friend Storer, in Massachusetts: "I am no longer Professor of Analytical and have given the Laboratory over to Allen and Mixter, simply sitting aloft among the thunder, a final Jupiter of reference."

THE FIRST LOCATION IN WESLEYAN UNIVERSITY

As we have discussed in chapter 1, "The Gestation Period," the first location of the station was at Wesleyan. A little more information is added here. In the 1877 report of the Board of Agriculture Atwater wrote:

> Arrangements were made by which the Professor of Chemistry at the College was relieved of a portion of his labor and enabled to assume charge of the work as Director. Early in October, soon after the opening of the College term, a chemist was upon the ground, and two others were afterward engaged so that of the first of January, 1876, the work of the Station was fairly started.... There was a bitter need of a better control of the trade in commercial fertilizer in the State. One of the chief arguments used in favor of the Station had been that by its means a fertilizer control system would be introduced, the demand that the first efforts should be turned in this direction was imperative.

The first three chemists, A. T. Neale, W. Balantine, and B. R. Griffin, received two hundred samples and reported on 162 that year. Two other chemists later at Wesleyan were E. H. Jenkins and George Warnecke.

A CENTURY OF ANALYTICAL CHEMISTRY

In the spring of 1877, the Legislature moved the Station to New Haven, sending E. M. Jenkins along. In the Annual Report for 1877, Johnson wrote: "The system adopted by the Station is that which for 20 years has worked well in Connecticut under the auspices of the State Agricultural Society and the State Board of Agriculture." Over the years the Station has analyzed fertilizers, feeding stuffs, food, drugs, toxic substances – you name it!

FERTILIZERS

Johnson's first bulletin, published in 1878, was, of course, on fertilizers. It contained an analysis of a fraudulent fertilizer sold by one Pollard. Pollard went on to be the first bad boy pilloried by fertilizer analysis. He moved from Connecticut to Rhode Island to Massachusetts, winding up in New Jersey, where he was arrested.

The first 50 years of analytical chemistry at the Station were covered pretty completely by Jenkins himself in his fiftieth anniversary year unpublished historical sketch written in 1925. Here are a few tidbits.

Over the years the Department has analyzed an astonishing array of substances mentioned as fertilizers: fish meal, leather, wool scraps, tankage (slaughter house waste), silk worm waste, castor pomace, bone, hair, horn, and all kinds of dung – horse, cow, pigeon, even elephant dung from Barnum's circus.

From time to time the chemists made interesting comments as they went along. For example, in 1890 they analyzed pigeon manure and wrote: "The dung of fowls contains not only undigested food, but also in solid form the excretions from the kidneys, which in cattle is voided as urine, and apt to be lost both by leaching and rapid fermentation."

FEEDING STUFFS

Armsby began to examine animal feeds from his first day at New Haven. I suspect that this accounts for Armsby's life-long interest in domestic animals. The report for 1895 says that he examined thirteen samples of feeds. In 1899, a new law on feeding stuffs was passed.

In the middle of this century somebody proposed to add various drugs to animal feed to promote growth. Merwin did pioneering work on methods for detecting these substances. For example, in 1954 he developed a method for analyzing sulfaquinoxaline, and in 1962 a method for arsanilic acid in feeds.

FOODS

Milk and butter were the first foods to come under scrutiny. As early as 1882, the chemists reported on the adulteration of milk. In 1895, the legislature passed a food quality law, and the report for 1896 contains seventy-eight pages of analyses of foods. They analyzed pepper, coffee, maple syrup, and ten other foods. Thirty percent of 848 samples were found to be adulterated.

The report for 1899 shows the effectiveness of their work in the decline of adulterated coffee as follows: 1896 – 63%; 1897 – 58%; 1898 – 24%; 1899 – 10%. Jenkins bragged, "The marked decrease is no doubt due to the work of this Station."

In 1893 Jenkins wrote, "I believe that this is the first agricultural experiment station to which has been committed by state law the work of examining food products" (p. 113).

The report for 1904 sounds a sadder note. "In the last nine years," it says, "the Station has examined 5983 samples of 61 different kinds of foods of which 2,052, a little more than one-third, are, in our opinion adulterated" (p. 105). "For some years the examination of food products ... seemed to have a detrimental effect on the makers of adulterated or mishandled articles, but this effect has now apparently ceased to follow" (p. 106).

The facts in this comment must have reached the Legislature, because in 1907 a new food and drug law was passed, and a year later, in 1908, only 7.3% were found adulterated. The new law seemed to lose its kick, too, because 24.7% of the foods were adulterated in 1909, 28% in 1910, 31% in 1912, 28% in 1916, and 24% in 1923.

DRUGS

The chemists began to examine drugs after the passage of the food and drug act in 1908. During that year, they examined two headache drugs, acetanilide and acetaphenetidine. The report said that they were dangerous. Aspirin was not mentioned until 1915.

These days we tend to think of heroin as a new threat to society. As early as 1912, however, Station chemists had to come down on addictive drugs. On page 159 of the report for that year they speak of heroin. "This" they wrote, "is diacetyl morphine which has recently come into use to an alarming extent as a substitute for cocaine and similar habit forming drugs. The abuse of these drugs has become so great that New Haven has passed an ordinance prohibiting its use except on prescription."

Two years later, in 1914, the report says: "The chemical department is being called upon frequently by the police to identify habit-forming drugs found in possession of those who trade in them illicitly."

TOXIC SUBSTANCES

Over the years the chemists have analyzed toxic substances in general, and especially toxic substances in food. The first with food was in 1882, when they found that the galvanized iron and copper kettles of the day released lead into the food cooked in them. Then, in 1883, they found arsenic in the stomach of a horse that had died suddenly.

Lead shows up again in the Analytical Chemistry department almost a century later. Hankin and Hanson in cooperation with the State Department of Health devised a "dip stick" method for measuring the urine of children to see if they had eaten lead paint. The city of Hartford congratulated Hankin and Hanson, saying that: "Messrs Hankin and Hanson are hereby commended for their tireless efforts in producing this significant breakthrough, in the detection of lead paint poisoning and thereby the prevention of mental retardation."

One could reasonably ask, "How could a contribution to mental retardation come from an agricultural experiment station that emphasizes research on plants?" It is a fascinating story. Biochemists know that the synthesis of chlorophyll in plants and hemoglobin, the red, oxygen carrying compound in animals' blood, follows the same pathway in both plants and animals until the last stage, chlorophyll in plants, hemoglobin in animals. Delta aminolevulinic acid is an intermediate in the pathway. If a child eats lead paint, the lead inhibits the conversion of the precursor to hemoglobin, and the unused compound accumulates in the urine. Presto! Take a piece of filter paper impregnated with an ion exchange resin, dip it into the urine, dry it, and mail it to the doctor or department of health for analysis.

By 1902 the chemists were discussing aniline dyes as coloring matter in foods. Some of these were poisonous or carcinogenic, or both.

The report for 1920 tells a sad story about toxic substances. Passage of the Volstead act gave the Station another task, the analysis of wood alcohol in whiskey. That report says that in 1919, one thousand gallons of wood alcohol in transit to England were highjacked in New York and used to mix with whiskey. This resulted in numerous deaths in Hartford during the Christmas celebrations that year. The amount of methanol in eight samples collected that year ranged from 31% to 47%.

THE SCENE CHANGES AGAIN

In the 'forties of this century society began to use organic pesticides to substitute for the old sulfur, copper, lead, and arsenic compounds. This led inevitably to the outcry about their presence in the environment. Rachel Carson made a million dollars or more on her book, *Silent Spring*, which is discussed in detail in the chapter on entomology.

In any event, it confronted the chemists with a new problem: analyzing foods for pesticides. In 1960, just before Thanksgiving, Secretary Fleming announced that cranberries for the traditional Thanksgiving meal were contaminated with the herbicide, aminotriazole. Kierstead and McLean, working two shifts a day and seven days a week, developed in sixteen days a method of analysis. The cranberries were saved.

In 1966, Fuzesi worked out methods for the quantitative analysis of mixed pesticide formulations.

When so-called "diet sodas" hit the market, the purveyors added glycine to mask the flavor of saccharin, the sugar substitute. Hanna and Coppola had to devise a way to measure the glycine.

About this time people began to worry about the nitrite in "corned beef." Nitrite, a preservative of long standing, gives corned beef its distinctive red color. In 1974, Coppola and Wickroski invented a fluorometric method for measuring nitrite in beef. And in 1963, Hankin and Wickroski found a way to measure lactose in preserved meats such as hot dogs and bologna.

Historical Markers along the Organizational Road

1857. S. W. Johnson appointed chemist to the State Agricultural Society.
1863. State Agricultural Society killed by the Civil War.
1866. State Board of Agriculture established; Johnson appointed chemist to the Board.
1869. Johnson published his famous book, *How Crops Grow*.
1875. W. O. Atwater, chemist at Wesleyan, first director and head of the laboratory of analytical chemistry.
1877. E. H. Jenkins, chief analytical chemist at New Haven
1903. A. L. Winton promoted to chemist in charge. Kate G. Barber first woman scientist at the Station.
1905. West wing of Johnson laboratory built.
1908. Winton resigned and J. P. Street promoted to chemist in charge.

1910. East wing of Johnson Laboratory destroyed by fire and rebuilt.
1920. Street resigned and E. M. Bailey promoted to chemist in charge.
1935. Biological testing of vitamin D begun.
1945. Bailey retired and H. J. Fisher promoted to chemist in charge.
1948. Memorial to E. M. Bailey in the Annual Report.
1955. Microbiological laboratory set up by Hankin.
1959. Owen Nolan first staff member to serve fifty years. Board of Control presented him a gold pin with diamond.
1967. H. J. Fisher retired; J. Gordon Hanna becomes chemist in charge.
1969. Centennial of Johnson's book. Renovation and modernization of Johnson laboratory begun.

The Professional Staff

S. W. Johnson	1856-1900	Owen Nolan	1909-1969
W. O. Atwater	1875-1876	R. B. Rowe	1910-1913
W. C. Tilden	1875-1875	C. E. Shepard	1910-1945
W. Balantine	1875-1877	L. Nolan	1910-1959
B. R. Griffin	1875-1875	G. L. Davis	1913-1917
A. T. Neale	1875-1875	R. T. Merwin	1917-1930
G. Warnecki	1875-1877	W. L. Adams	1917-1918
E. H. Jenkins	1876-1923	M. D. Esopo	1917-1919
H. P Armsby	1876-1881	H. D. Edmond	1918-1923
W. H. Jordan	1877-1877	R. E. Andrew	1920-1927
H. L. Wells	1878-1880	H. J. Fisher	1921-1957
C. H. Hutchinson	1879-1884	W. T. Mathis	1924-1858
G. Archer	1882-1884	D. C. Walden	1927-1957
E. H. Bojardus	1883-1884	R. Hubbell	1937-1953
E. H. Farrington	1883-1888	R. T. Merwin	1938-1967
M. Whitney	1884-1884	H. Kocaba	1944-1988
A. L. Winton	1884-1908	A. Wickroski	1945-1984
T. B. Osborne	1886-1888	L. E. Kiersted	1945-1977
A. S. Curtis	1888-1893	R. A. Botsford	1949-1958
A. W. Ogden*	1890-1908	S. Squires	1949-1985
C. Vorhees	1892-1893	W. O. Mueller	1958-1969
H. M. Smith	1893-1894	R. A. West	1959-1973
W. G. Mackenzie	1908-1908	M. Fuzezi	1965-1989
C. A. Brautlecht	1908-1909	J. G. Hanna	1967-1984
C. Rodman	1908-1909	W. Glowa	1969-1984
J. P. Street	1906-1920	E. Coppola	1972-1979
E. M. Bailey	1908-1945	L. Hankin	1954-Date

**NOTE. According to a New Haven historian, Ogden Street off Whitney Avenue in Hamden is named for A. W. Ogden.*

6 Genetics

Without doubt, Jones's invention of the method of producing hybrid corn was the most valuable contribution ever made by the Station, probably the most valuable by any station. North Carolina published the history of its station in 1979. On p. 23, it states: "When agricultural leaders want to impress the public with gains in agricultural productivity, they usually cite 'the Corn Story.' It is a dramatic story – a tale of how agricultural research has helped farmers to grow four grains where one grew before." Our Station report for 1963 notes that "Jones's discoveries in hybrid corn have resulted in a net increase in wealth of 904 million dollars, for that year. This is 10% of the National Budget."

Henry Wallace, who put together the first company to produce hybrid seed corn commercially, expressed his admiration for Jones and the Station in a speech entitled *Small Plots and Big Men* at the Station Summer Field Day in 1955. The Station printed this address in one of its circulars (No. 198). Among other things, he said:

> No State Agricultural Experiment Station has ever accomplished so much with so little land, money, and salaries. The marvel is that Connecticut, which is about thirty-eighth in corn acreage, should have, during the first twenty years of this industry, done perhaps as much for corn as the great Corn Belt State Experiment Stations in states where they grow fifty to one hundred times as much corn as Connecticut, and where their experimental farms are far larger, their appropriations greater, and their scientific personnel more numerous.

Paul Mangelsdorf, Jones's former graduate student, wrote his biography as a memoir of the National Academy of Sciences. Among other things, he wrote, "If there were a Nobel Prize in agriculture as there is in medicine, it would undoubtedly have been awarded many years ago to Donald F. Jones for his part in the development of hybrid corn. In 1968, the station tried to get him nominated, but could not find a Nobel Laureate to help out."

CORN BEFORE THE STATION WAS FOUNDED

Corn is an Anglo-Saxon word meaning the small hard seed of a cereal. In England it refers to wheat; in Scotland and in Ireland, to oats. When the English came to America, they found a new hard-seeded grain which they called Indian Corn. The Indians (who called it maize) taught the settlers to plant the corn in hills and put a fish in every hill to nourish the plants. This calls to mind an old bit of doggerel about planting corn: the colonists planted five seeds to a hill: "one for the bug, one for the crow, one to rot, and two to grow."

Donald R. Jones and Henry A. Wallace

Summer Field Day at Mount Carmel - 1955

On the 40th Anniversary of the first "double-cross" corn

The first printed reference to corn in Connecticut that can be found is in a lecture by Thomas B. Butler in the Proceedings of the State Board of Agriculture for 1856. He complained about the decline in productivity of Connecticut soil, and supported his case with a table showing the productivity of various crops and animals between the census of 1840 and that of 1850. For example, the production of wheat fell from 87,000 bushels to 41,000 bushels. At the same time he noted an increase in the production of "Indian Corn" from 1.5 to 1.9 million bushels.

As might expected, Johnson put a speech on corn into his three-week short course on agriculture at Yale in 1860. It was delivered by Joseph Harris, noted seedsman from near Rochester, New York. His title was "Cultivation of Wheat and Indian Corn."

Corn shows next in a symposium on the crop in the Proceedings of the State Board of Agriculture for 1871. Here are a few excerpts:

> Indian Corn is our great national cereal and its cultivation is adapted to a wider range of latitude and elevation than any other kind of grain. [Corn must have as wide a range of genes as the dog].... Corn is a great exhauster of the land and the yield per acre [is] continually going less.... Thirty, forty-five, and fifty bushels are my largest crops ... The amount of corn raised in the United States in 1869 was a thousand million bushels.... The average price throughout the United States was fifty-five cents a bushel. That would be $550,000,000 as the value of the crop. We talk a great deal about the National Debt. Well less than four years of our corn crop would wipe it out.

The Proceedings go on to say that Mr. T. S. Gold "exhibited some large and well formed ears," that he had produced "by crossing Early Vermont and Early Prolific." Gold had a long lead on Jones. When the Station was established, Dr. Gold was appointed to the first Board of Control.

CORN AFTER THE STATION WAS FOUNDED

Soon after it was founded, the Station began work on corn. As early as 1878 Jenkins reported on an analysis of corn fodder, and the 1890 report says that Jenkins was experimenting with "Indian Corn" on the farm of J. H. Webb. (Webb's farm is now the shopping center of Spring Glen.) Jenkins was studying the effect of continuous growth on the same land and the "effect of rate or distance of planting on the quantity and quality of the crop."

The same year's report adds that "the careful examination of the albuminoids of Indian Corn made ... by Professor R. H. Chittenden [of the Sheffield Scientific School] and Dr. Osborne, jointly are in the course of publication." Here begins the biochemical part of the saga of corn. This will be discussed in the next chapter.

In the report for 1907-1908, East said that he had "made a canvass last winter to find varieties of flint corn which seemed most promising for breeding, and during the summer seven such varieties have been tested." Here began the saga of corn breeding.

Let us turn now to the Saga of Corn, slightly edited, from an article in the *Journal of the New Haven Colony Historical Society*.

THE LEGEND OF THE CROW

A fascinating legend about the crow was recorded by Roger Williams of Rhode Island *circa* 1650:

> These birds, although they do the corne some hurt, yet scarce one native in an hundred will kil them, because they have a tradition that the crow brought them first an Indian graine of corne in one eare and a 'French beane' in the other from the great god Cantantowitz's field in the Southwest from whence, they hold, came all their corne and beanes.

Most geneticists agree with the crow that corn originated in the Southwest. The crow lived up to his tradition as a wise old bird. He sensed that corn is an incomplete food for people: it needs the protein in the bean as a supplement. In effect, that crow invented succotash. It took nearly three hundred years, from Roger Williams in Rhode Island to Thomas B. Osborne and Lafayette B. Mendel at The Connecticut Agricultural Experiment Station, to find out why.

The corn-bean interaction will be discussed in two parts: the Station's research on the genetics of corn and the Station's research on the biochemistry of proteins.

THE ROAD TO HYBRID CORN

Like Wallace, we wondered how the secret of the commercial production of hybrid corn came to be discovered in Connecticut, a long way from the corn belt. The story goes like this....

In December 1903, Director Jenkins read a paper, "The Corn Crop in Connecticut," before the State Board of Agriculture at its annual meeting in Hartford. He said in part: "The corn crop is our staple cereal ... it covers almost 50,000 acres ... there will always be a demand for milk in Connecticut ... and corn is the cornerstone of a paying dairy interest."

In the summer of 1905 Jenkins took a hot, dusty train to Urbana, Illinois to interview E. M. East, whose work under Professor C. G. Hopkins on breeding corn for more protein was being abandoned. Jenkins was surely farsighted. Just as Hopkins was giving up on corn breeding in Illinois, Jenkins put his faith in it for Connecticut. (An ironic coincidence: Jenkins's middle name was Hopkins.) Using some of the Adams funds that came his way in 1905, Jenkins hired East by letter of July 11, almost thirty years to the day after Governor Ingersoll signed the bill creating the Station. Jenkins wrote: "Our object in inviting you to join us is to have you engage at once in the study and practice of corn breeding in Connecticut." (Note Johnson's principle of marrying theory and practice.) And in adding, "I wish you to take the management of the work on yourself," Jenkins gave East independence, and proposed a conference for early September: "Any time after September 4 would suit me," he wrote.

Although I can find no minutes of this conference, this is what I think went on. Both Jenkins and East were chemists. When they met, they almost certainly discussed the proteins of corn, because that is what East had worked on in Illinois. Jenkins reminded East that his colleague, Osborne, had considerable experience with proteins. Osborne would surely have been invited to the conference, but he was on summer vacation in New Hampshire. East must have agreed that it would be a good idea to get Osborne into the picture.

This accounts for the letter Jenkins wrote to Osborne in New Hampshire on September 9, right after the conference. "Dear Doctor Osborne, I wish you had a couple of men in your laboratory now for six weeks with nothing to do. I should like to see them tackle the 'proteids' in corn." Osborne undoubtedly accepted the challenge. (That work will be discussed in the next chapter.)

It is probably significant that East was a chemist who had been transformed into a corn geneticist. Particularly in trying to create new substances, chemists like to use "chemically pure" compounds as starters. East must have decided he needed the equivalent in his work with corn. As he hoped to create a new corn with more protein, where could he obtain "genetically pure" strains as starters?

While still at the University of Illinois, he began in 1904 to inbreed corn varieties by putting pollen from the tassel of one plant on the silks of its own ear. Inbreeding, however, weakened his plants. Inbred plants were smaller than their parents. To Hopkins this was going backward, and he abandoned the project. East brought his first generation inbreds with him when he came to Connecticut in 1905.

In New Haven, East crossed his inbred pure lines and discovered what to him, as a chemist, must have looked like a brand new "compound." The progeny were much larger, more productive, and more uniform than the original varieties from which they had come. All this elegant theoretical work fit nicely into the first part of Johnson's dictum that theory and practice must march together. But where was the practice? Easy! All the seedsman had to do was to cross the inbreds and sell the seeds of the high-yielding progeny to farmers. Alas! as East could see, this would not work because the seedsman would have to plant two or three acres of scrawny inbreds to get enough seeds to sow one acre for the farmer, and that is where the matter stood for several years.

East discovered the work on breeding corn by George Harrison Shull at the Carnegie Institution of Washington in Cold Spring Harbor across Long Island sound from New Haven. They visited each other occasionally. Shull found that East had begun inbreeding in 1904, a year before himself, but was not interested in making the work practical. Shull moved to Princeton and gave up experimenting with corn; about the same time, East moved to Harvard, though he did not give up his interest in corn genetics.

IN THE LAND OF THE SLEEPING GIANT

Director Jenkins would not give up, either. He seemed to sense that the Station's policy of melding the theoretical with the practical would one day find someone to solve the problems of making hybrid corn practical. Jenkins purchased, partly for work on breeding corn, a tract of land in the town of Mt. Carmel within sight of Sleeping Giant Mountain. Hybrid corn can be considered a sleeping giant awakened. But the problem of commercial production drifted until 1915, when Jenkins hired a boy from Kansas who had come to study under East at Harvard. His name was Donald F. Jones.

With the brashness of youth, Jones leaped right into the face of the genetic dogma that you don't cross crosses. A cross, by definition, is a mixed-up organism. Crossing two crosses would surely result in a genetic mess! Jones reasoned that, if the seed production problem could not be solved by crossing two scrawny inbreds, say A and B to give AB, or two others, say C and D to give CD, why not then cross AB with CD? That is what he did in 1917. In the next crop year of 1918, he found to his delight that the yield of ABCD far outyielded that of AB or CD, or that of their respective parents as well. This became known as the double cross.

Jenkins's persistence had paid off fifteen years after his percipient paper before the State Board of Agriculture in December 1903. He must have been terribly excited, but there is no record that he ever said so. He was too modest for that.

Jones published his double cross method in 1919. He had made a beautiful discovery, but how could a farmer get seed to plant in his fields? Farmers could not easily do all the necessary inbreeding and crossing. Jones pushed that aspect, too. He persuaded George F. Carter, a farmer in nearby Clinton, to produce seed this way. Carter did so for a year or two, but did not have the capital to make it go.

H. A. WALLACE ENTERS THE PICTURE

Henry Agard Wallace of Iowa, later to become Vice-President of the United States, provided the solution to that problem. He read

Jones's article and proceeded to create a company to do all the chores. He called it the Pioneer Hibred Seed Company.

In 1955, the fortieth anniversary of Jones's appointment to the Station staff, Wallace was invited to speak at the annual Summer Field Day at the Station farm in Mt. Carmel where the first double cross had been made. He titled his speech "Small Plots and Big Men."[10] Wallace said that he took some of Jones's inbreds back to Iowa and melded them with some of his own to form the basis of his new company. He laughingly told the audience that later he got some sort of medal for the work – whereupon Jones had joshed him, saying, "You used some of my inbreds for that venture – the medal must be half mine." Wallace sent him the medal which, of course, Jones returned.

In 1984, the journal *Science 84* asked William Brown, then President of the Pioneer Hibred Seed Company, to write this story up as one of the magazine's "40 Discoveries That Changed Our Lives."[11]

Jones turned next to the theoretical aspect of hybrid corn in consonance with Johnson's principle. His explanation of the genetics of hybrid vigor brought him scientific kudos and eventual election to the National Academy of Sciences.

THE RESTORER GENE

It is not unexpected that bright ideas will emanate from young men. But Jones went on to generate another bright idea late in his life. A messy chore for seed corn companies was to detassel the female parent of a cross. The company would plant six rows of the female parent and one row of the male parent. At detasseling time, hordes of high school students were sent through the crossing fields to yank out the tassels of the six female rows so that they would be pollinated from the single male row.

Jones fretted for years about how he could eliminate this serious bottleneck in growing hybrid corn. Then one day, John Rogers, working in Texas under Paul A. Mangelsdorf, a former student of Jones, discovered a stalk of corn that produced sterile pollen. Mangelsdorf suggested to Jones that this was the answer that Jones had been seeking. Jones proceeded to incorporate this feature into the female line. There would be no need to detassel. The pollen would be sterile. This idea fell flat on its face, however, because this type of pollen sterility is inherited, not through the genes, but through the cytoplasm, and, therefore, through the seeds produced by the female line. If a company produced hybrid corn that way, the cytoplasm of the seed would carry the sterility feature. The farmer would get no grain, because his crop's pollen would be sterile, too.

Jones, being a geneticist, decided that there must be a gene that would nullify the sterility, and began to search for a "restorer gene." He eventually found one and incorporated it into the genome of the male parent. When he inserted this gene into the male line, it canceled the sterility factor in the progeny, and the farmer's seed was fertile. This was his second great contribution to hybrid corn.

The restorer gene was very quickly adopted by seed corn companies. And this suggested an idea to Jones: he would patent its use. Jones was always a quiet, gentle man. One could hardly imagine him entering the hurly-burly of the patenting business. The station tried to talk him out of it, but, no sir!, he would do it. He explained that he had always felt slightly ignored by his competitors in the Midwest. He would show them! In about 1958, he and Mangelsdorf applied for the patent, which they assigned to the Research Corporation of New York. After a long fight the patent was issued and the corn companies paid off.

THE SAGA OF CORN, CONTINUED

There is more to the saga of corn. As we shall see in the next chapter on Biochemistry, Osborne and Mendel discovered that corn is deficient in the amino acids lysine and tryptophan. This discovery cast another challenge before the geneticists. There must be a gene or genes in all that marvelous bag of genes in the corn nucleus to control the synthesis of lysine and tryptophan. Jones did not rise to this challenge, but it did provoke one of his former graduate student technicians, Oliver Nelson, who had moved to the Purdue Agricultural Experiment Station in Indiana.

One day in 1968, Nelson was chatting with Edwin Mertz, a biochemical colleague at Purdue. Yes, they agreed, there must be a gene or genes that would do the job. They decided to look for some oddball grains of corn. Nelson remembered one from his days in Jones's experimental field plots in Mt. Carmel. It was labelled "Opaque II," opaque because the grain is opaque and not normally translucent, and Opaque II because there was an earlier Opaque I. A farmer in Enfield, Connecticut, had sent this funny-looking corn to the Experiment Station in the middle 'twenties. Jones and Singleton, being pack rats of sorts, had saved it, and Nelson got a sample nearly forty years later. Nelson's colleague, Mertz, analyzed it and, lo and behold, it carried genes for lysine and tryptophan!

The saga of corn had still other episodes, too. The report for 1936 says that ten years before, in 1926, the Station introduced the first crossed sweet corn in the world. Sweet corn farmers like to sell their product all through the summer. A single variety wouldn't do. Singleton set out to remedy this situation, and developed three crossed varieties – early, medium, and late – which he named Marcross, Spancross, and Carmel Cross.

In 1970 hybrid corn suddenly hit a snag. A leaf spot fungus developed a mutation that enabled it to parasitize corn produced by seed with cytoplasmic pollen sterility (the so-called Texas cytoplasm). That year the fungus killed about fifteen percent of all the nation's corn. The nation's corn breeders climbed on top of the trouble very soon, however, and saved the crop.

In the early 'forties, Nelson and another graduate student, Lewis F. Roberts, were working at the Station as technicians under Jones. Looking for root rot resistance, they made a habit of kicking over the stalks at the end of the season. OUCH! One stalk wouldn't kick over: it was resistant to root rot. It was a plant from the Lancaster Sure Crop variety, which they named C-103, C representing Connecticut. The 1957 report of the Station says that "a survey by the USDA for the last ten years shows that C-103 has entered into the production of more hybrid seed corn produced in the U.S. than any other release." It is used in many countries.

OTHER CROPS

The Genetics Department has not limited itself to corn, of course. Like the other departments, from time to time it had worked on tobacco. In his days at the Station early in the century, East applied himself on tobacco breeding.

In 1951 a new disease, called "weather fleck," hit the tobacco in the Valley. Seaward Sand sought and found genes for resistance to the disease. The Report for 1970 says that "these genes have saved the industry from disaster." Without this discovery, farmers would not be able to grow tobacco in the Valley today.

When Curtis came in the late 'twenties, he began breeding cucurbits, and soon introduced a new variety of squash called "Connecticut Straight Neck." In 1935 his "Windsor Pepper" won an Award of Merit from the American Seed Trade Association. In 1941 the Station released his "Yankee Hybrid" squash. In 1949 Curtis was awarded a gold medal by the American Seed Trade Association for his work on squash breeding.

Arthur D. Graves of the Brooklyn Botanic Garden served as an adjunct scientist at the Station for many years, beginning in the 'thirties. He worked to breed blight-resistant chestnuts. He obtained resistant genes from the Chinese varieties, but was never able to convert their bush type to our telephone pole type. When writing his will, he proposed to give his house and land adjoining Sleeping Giant State Park in Hamden to the Station. At our suggestion, however, he left it to the State to become a part of the Park, with the proviso that the station could use it for chestnut blight research. The short street past his land is now called "Chestnut Lane."

PETER DAY ARRIVES

In 1964 Peter R. Day, an Englishman, arrived at the Station. He was a fungal geneticist, having worked on the fungus that causes tomato leaf mold. Day began work on the corn smut fungus. He was never able to grow the diploid phase of the fungus in culture, although he could easily grow the haploid phase. This was a fortunate circumstance, because it enabled him to cross strains by simply juxtaposing them in an agar plate. He called this "plate mating."

In crossing two particular haploid strains, he noticed that one strain inhibited the growth of another. He called this the "inhibitory factor," and soon showed it to be a big protein, which eventually was thought to be a virus. Interestingly, the effect of the inhibitor could be canceled by incorporating activated carbon into the medium. Day also attempted to introduce a gene for smut resistance into corn, using genetic engineering techniques.

In 1957 Carl D. Clayberg came on board and took up tomato breeding. Since male sterility was a prominent subject of the day, he hoped to use it in tomato breeding, if for no other reason than that commercial breeders hated to remove the anthers from the tiny tomato blossom by hand. He found a pollen sterile type as well as a linkage between pollen sterility and a green stem marker on chromosome 2. This enabled him to identify pollen sterility in seedlings, an idea he introduced to commercial breeders.

Clayberg also contributed to the breeding of African violets, for which he was recognized by a bronze medal from the African Violet Society of North America.

Richard A. Jaynes attained fame in breeding the mountain laurel, the State Flower of Connecticut. He made many crosses to study the inheritance of color in the petals and found that the red color is due to a single gene.

Jaynes worked strenuously to restore the chestnut to Connecticut. While Graves was still alive, they cooperated on the research. Work on the chestnut brought him in contact with the Northern Nut Growers, and he edited a book on nuts. In 1971 Day ran across the French research on hypovirulence in chestnut blight fungus. This was exciting because it offered an opportunity to control the disease. As of 1988, practical control is still elusive, but still promising.

In the 'sixties genetic engineering became a hot subject in genetics. Anagnostakis, with her competence in culturing organisms, entered the field. She was able to grow haploid plants from the anthers of the tobacco plant.

Historical Markers along the Organizational Road

1903. Jenkins launched the Saga of Corn in his speech on corn before the State Board of Agriculture.

1905. Jenkins appointed E. M. East as the first "agronomist."

1909. East went to Harvard. H. K. Hayes replaced him.

1910. Name of Department changed to Plant Breeding.

1915. Jones replaced Hayes.

1917. Jones published theory to explain the phenomenon of heterosis. "[His] method of seed production made it feasible and his theory of heterosis made it plausible." Jones made the first double cross.

1918. Jones planted and harvested the first double cross at Mt Carmel.

1919. East asked Jones to join him in his book *Inbreeding and Outbreeding*.

1921. Mangelsdorf arrived as graduate student under East, his salary paid by the Station.

1927. Singleton joined the staff to work on sweet corn.

1929. Curtis joined the staff to work on vegetables.

1933. "By 1933 hybrid corn was in production on a substantial scale." By 1959 more than 95% of the nation's corn was hybrid.

1939. Department name changed to Genetics.

1944. Mangelsdorf proposed using pollen sterility in corn breeding.

1954. Jones found "restorer gene" to nullify sterility in farmers' crops.

1955. Wallace spoke at Mt. Carmel Summer Field Day honoring Jones.

1958. Jones and Mangelsdorf applied for a patent on restorer gene.

1960. Jones retired. Harry Stinson made head of the department.

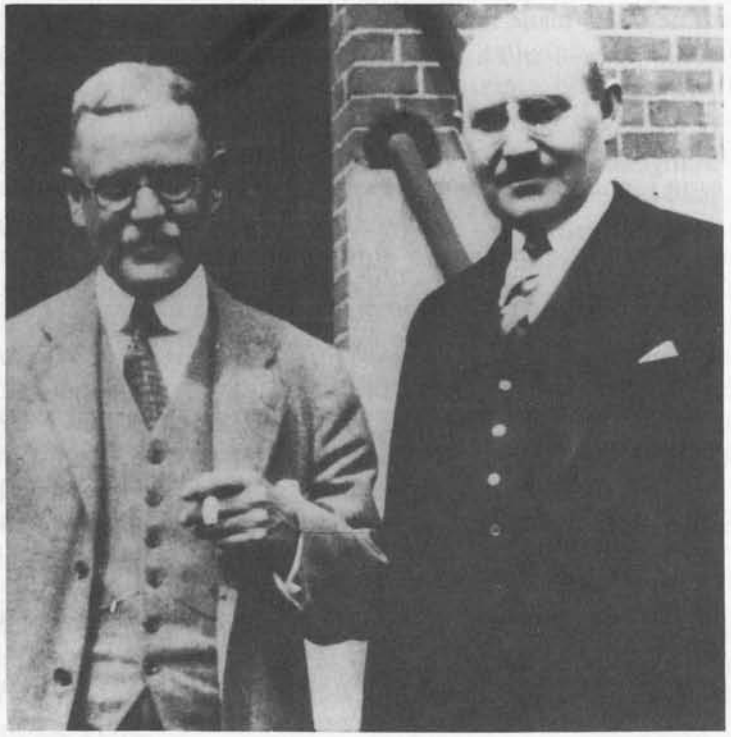
1964. Stinson resigned. Peter R. Day succeeded him.

1969. Patent issued. Part of the Station's portion of the income used to redesign hall now named *Jones Auditorium*.

1971. *Helminthosporium* differentially attacked pollen sterile corns and killed 15% of the nation's corn.

The Professional Staff

E. M. East	1905-1909	R. A. Jaynes	1961-1975
H. K. Hayes	1909-1915	P. R. Day	1964-1979
D. F. Jones	1915-1964	J. E. Puhalla	1965-1970
P. C. Mangelsdorf	1921-1926	W. L. George, Jr.	1966-1971
W. R. Singleton	1927-1957	S. Anagnostakis	1966-Date
L. C. Curtis	1929-1957	Janet Kerr (visitor)	1966
A. H. Graves (Adjunct)	1934-1962	L. D. Incoll (visitor)	1967-1969
H. T. Stinson Jr	1952-1962	J Ebinger (visitor)	1970
Uheng Khoo	1953-1962	A. Goldsworthy (visitor)	1970
S. C. Sand	1954-1964	J. Pollacco	1974-1979
C. D. Clayberg	1957-1974		



Thomas B. Osborne and Lafayette B. Mendel.
Discoverers of the first "Vitamin"

7 Biochemistry

We generally think that biochemistry at the Station began in 1888, when Director Johnson asked T. B. Osborne to conduct research on proteins. Actually, I think that the Station touched biochemistry, tentatively at least, in 1877, when Johnson appointed H. P. Armsby to his first staff upon removal of the Station from Middletown to New Haven.

Armsby was born September 21, 1853, in Northbridge, Massachusetts. He came to Yale to work on chemistry under Johnson and took his BS degree in 1874 and his PhD degree in 1879. Armsby was the second person (after Jenkins) whose graduate work was subsidized by the Station. Because they had worked together in Germany, it is probable that it was Jenkins who urged Johnson to appoint Armsby to the Station staff. With Johnson, Armsby published the first Station bulletin (No. 34) not devoted to fertilizer analysis to prevent fraud. Entitled *Analysis of Hay*, it was hardly a monograph. It consisted of only one page. Nevertheless, with only a modicum of imagination, this can be called the first research publication of the Station.

In 1883 Armsby moved to the University of Wisconsin, where he became Associate Director of the new (pre-Hatch) experiment station there. He undoubtedly carried with him Johnson's dictum that theory and practice must march together, which helped to establish the Wisconsin Station as one of the most distinguished in the Nation. He did so well in Wisconsin that, in 1887, he was invited to Pennsylvania to establish a new Experiment Station at Pennsylvania State College. He was elected to the National Academy of Sciences in 1920 and died on October 19, 1921.

OSBORNE IS APPOINTED

T. B. Osborne, known as "Mr. Biochemistry" at the Station, never analyzed fertilizers. Johnson used some of the newly arrived Hatch funds to help pay Osborne, and appointed him to work on soils. In 1888 he asked him to study protein, a topic Osborne followed for the rest of his life.

Osborne's work was the epitome of pure science. He exerted a tremendous influence in enhancing and maintaining the theoretical half of Johnson's dictum that theory and practice must march together. In 1910 he became the first post-Johnson staff member elected to the National Academy of Sciences. Looking back on the twenty-five-year-old little Experiment Station as it was at the end of the nineteenth century, it is hard to believe that the taxpayers of Connecticut would have supported Osborne's pure research on the chemistry of proteins. One wonders what Director Johnson's reply may have been when some farmer legislator (of which there were many) must have asked, "Of what good is all that work on the albuminoids in the seeds of oats, flax, and cotton. We don't even grow cotton in Connecticut." Later, Jenkins must have had to answer similar questions about "the nucleic acid in the embryo of wheat, or the globulin of the English walnut."

On receiving a gold medal in 1928, Osborne said, "During those (early) years none of my fellow chemists seemed to take any interest in my work; in fact many of them intimated pretty plainly that I was wasting my time working in a hopeless field. When I see how many different directions the results of the work which I started here have been applied, I am astonished." Dr. Osborne, your scientific grandchildren salute you!

In forty years at the Station, Osborne published only one Station bulletin to report his work. This early bulletin, No. 105, is entitled, "The proteids or albuminoids of the oat kernel." Two items in his bibliography, however, leap from the page at you: "The Food Value of Milk and Vitamins" and "The Life-Giving Food Elements." Both were published in a farm journal, *The Rural New Yorker*.

When he died, Osborne's reputation received warmly favorable notice in an editorial in *The Experiment Station Record*, a publication of the USDA. It gave credit to his associates at the Station for saving him from destruction by the pragmatists. The editorial says:

> Outstanding among these have obviously been Director Johnson at whose instigation and under whose enlightened leadership the investigation was originally conceived and gotten underway, and his successor, Director E. H. Jenkins, who without the incentive of project authorship, assumed the responsibility for its continuance and suffered no interference with its progress. Nor should there be overlooked the consistent cooperation of successive Boards of Control, manifested through the years when results came slowly and the application to practical farming seemed remote and improbable. If it is recalled that even after the passage of the Hatch Act the entire resources of the Station did not exceed $20,000 per annum for several years, that the Experiment Station itself was on trial in Connecticut as elsewhere, with its usefulness to agriculture still to be fully accepted, and that a host of relatively simple problems of undoubted economic importance and popular appeal were pressing for solution, the courage and vision of Dr. Osborne's supporters become manifest.

Five points bear on the explanation. First, much of the cost was borne by the Carnegie Institution of Washington (beginning in 1902) and by the Adams fund (beginning in 1906); these funds were not available to Johnson in the 'nineties, of course. Second, as early as 1855, Johnson had said that "Theory and Practice Must March Together." Third, in the first report of the Station Atwater had written: "It has been felt from the first that the more abstract scientific investigation would afford not only the proper, but also the most widely and useful work of an experiment station." Fourth, the association with Yale encouraged the high intellectual level needed. And, fifth, Osborne had an independent income.

WHO WAS OSBORNE?

Thomas Burr Osborne was born to a prominent New Haven family on August 5, 1859. His ancestor, the Reverend James Pierpont, was pastor of the first church built in New Haven, in 1684. Osborne certainly came by his inventive genius naturally: his great, great uncle was Eli Whitney, inventor of the cotton gin, and one of his grandfathers was Eli Whitney Blake, the inventor of the stone crusher.

The Osborne family was long associated with the Second National Bank of New Haven: his Osborne grandfather was a director from its origin in 1864 until his death in 1869. His father was a director from 1869 to 1916, and president for seventeen of those years. Thomas Burr was made a director when his father died and he served until his own death. When he died in 1929, he left the Station a sizable legacy.

Osborne prepared at the historical Hopkins Grammar School, received his bachelor's degree from Yale in 1881, and the same university's tenth PhD in 1885. (Armsby's PhD in 1879 must have been Yale's third or fourth.) Yale awarded Osborne an honorary DSc in 1910.

Even as an undergraduate, Osborne showed his inventive genius. One of his fellow Yalies was a miller's son. From him he heard about the difficulty of separating the chaff (bran) from the grain. One day, while tamping tobacco in his pipe with a gutta percha-tipped pencil, he noticed that ash clung to the eraser. He promptly invented a machine with a rubber roller which was electrostatically charged as it passed over a row of sheepskin brushes. The bran flew up to the roller, leaving the wheat kernels behind. He was granted patent No. 224,719. Millers used this machine for several years.

His practical streak surfaced again in 1886, when he married Elisabeth Anna Johnson, Director Johnson's daughter, and was made a member of the Station staff. Osborne was off and running. Vickery wrote: "One vacation day in August of that year (1888), while walking up the hill to his summer home in Holderness, New Hampshire with his son-in-law, Johnson proposed that an investigation of the proteins of seeds should be undertaken. The young man eagerly assented." He decided to attack the oat kernel, a project researched by Norton in 1845.

ANALYSES OF SEEDS FOR PROTEINS

Trained as an analytical chemist, Osborne spent his time until 1901 analyzing the seeds of 32 species of plants for proteins. His analyses depended on the solubility of the proteins in water and salt solutions. During this time he called them albuminoids, proteids, globulins, proteoses, and proteins. By 1899 he began to progress from listing the proteins in numerous plants to describing their chemical structure. Vickery, in Bulletin 312 (p. 362) wrote: "The descriptive studies were followed by several papers dealing with the nucleic acid in the wheat embryo.... He showed that it contained the purines, guanine and adenine in molecular proportions." It should be noted that he dealt with the embryo, the reproductive portion of the seed. It is too bad that he did not live to see the discovery, a half century later, that genes controlling heredity are made up of nucleic acids arranged in a double helix.

ANAPHYLAXIS EXPLAINED

In the period when he was purifying proteins to study their chemistry, Osborne received a letter from H. Gideon Wells, of the University of Chicago Medical School, requesting some pure proteins to use in studying the phenomenon of anaphylaxis. Wells knew that he could safely inject an animal with a protein, but if he later injected a second dose, the animal would die. This is anaphylaxis. Together, Wells and Osborne published eight papers on anaphylaxis. The first, entitled "The Biological Reactions of Proteins. I. Anaphylaxis," was published in the *Journal of Infectious Diseases*.

NUTRITIVE VALUE OF PROTEINS

The arrival of Lafayette B. Mendel in 1909 shifted the direction of Osborne's research toward a third phase, dealing with the nutritive qualities of proteins. His first publication in this area appeared in 1911, *Feeding Experiments with Isolated Food Substances*.

In the preceding chapter, "Genetics," we pointed out that Osborne's studies of nutrition stem from Jenkins's 1903 article on corn in the Proceedings of the State Board of Agriculture, the beginning of the SAGA OF CORN. That saga's second half centers on Osborne and biochemistry. As recounted earlier, Jenkins hired E. M. East in 1905 to work on the genetics of corn. Shortly after East arrived, he and Jenkins held a conference. Being chemists, they agreed to ask Osborne, the protein chemist, to look into the proteins of corn. It seems that Osborne enthusiastically agreed. He probably did not know the legend of the crow with a grain of corn in one ear and a bean in the other, but his work would one day put a scientific base under the legend, the need for "essential" amino acids.

Osborne had known for some time that proteins are built up of units called amino acids. In 1908 Osborne and S. H. Clapp published their finding that the protein in the corn seed is low in lysine, and to a lesser extent, in tryptophan. Did the levels of these amino acids affect the nutritive value of corn?

After Mendel arrived from Yale, they set out to answer this question. First, Osborne and Mendel had to find some animals to feed. Corn is grown to feed cows and pigs, but they could not grow cows and pigs in the city of New Haven. Besides, these animals reproduce too slowly.

Osborne and Mendel took the easy way out: they bought some white rats from a pet store in downtown New Haven and set out to solve a farmer's problem with the rat – an animal farmers despise.

For their experiments, they took large litters of rats after weaning and divided them into two lots. They then fed half the rats on a standard milk diet, and the other half on the experimental diet.

SIGNIFICANCE OF AMINO ACIDS IN NUTRITION

Rats fed exclusively on corn grew slowly and eventually died. Clearly, corn was nutritionally deficient. Knowing that corn protein is low in lysine and tryptophan, Osborne and Mendel fortified the corn diet with these amino acids for a second experiment. To their delight the rats grew much better, but still not as well as those on the milk diet. They reported this to the scientific community in 1913, eight years after Jenkins had persuaded Osborne to look into the proteins of corn.

This research established, for the first time, that an animal can not synthesize lysine or tryptophan for itself, but must get them from its food. These proteins are known as "essential amino acids." We now know that mammals – humans included – must obtain certain essential amino acids in their diet, although they can synthesize some others that they need. And that is why the crow had to bring a bean along with the corn to feed the Indians. The bean provided the essential amino acids missing in the corn.

WHY IS MILK A PERFECT FOOD?

Like all research, that on corn raised as many questions as it answered. The rats grew perfectly well on milk. Everybody knew that milk was a complete food for mammals. It was time for Osborne and Mendel to look into that, too. Were all ingredients in milk of equal importance? The answer to that question provided another dramatic understanding of animal nutrition. Step by step, Osborne and Mendel would determine the effectiveness of the ingredients in milk: casein, minerals, water, sugar, and fat.

DISCOVERY OF VITAMIN A

When they substituted other proteins for the casein, minerals from the laboratory shelf for the minerals, distilled water for the water, and cane sugar for milk sugar, the rats survived. But fat was different. If they substituted lard for butter fat, the rats grew poorly. How does lard differ from butter fat? Butter fat is yellow. If they took only the yellow substance from butter and added it to lard, they got dramatic results. The rats grew normally.

In 1913 they published their finding that the yellow substance in butter fat is essential for growth in animals. This substance later came to be called Vitamin A. Today's newspapers are full of stories about the benefits of eating yellow vegetables. In due course, others would discover vitamins B, C, D, E, etc.

The discovery of vitamin A illustrates a not-uncommon aspect of science. Elmer C. McCollum, Mendel's former student, went to the Wisconsin Agricultural Experiment Station, where he also worked on animal nutrition with white rats. He, too, wondered why milk was a perfect food and, following a route parallel to Osborne and Mendel's, he also discovered vitamin A. He beat Osborne and Mendel to the draw, however, publishing his results in the same journal as Osborne and Mendel, but three weeks earlier.

Osborne and Mendel might have discovered vitamin A earlier. In 1911, Osborne noticed that some of his rats were afflicted with an eye trouble, and wrote: "The eyelids are stuck together ... and the eyeball appears dry." He came close that day to discovering vitamin A, but as we might say today, "he blew it." He thought the eye trouble was a bacterial infection, when it was really a type of night blindness caused by vitamin A deficiency. In 1913 they found that butter would cure this eye disease. In World War I, fighter pilots took vitamin A to reduce night blindness.

AND NOW TO LYSINE GENETICS

With the wonderful benefit of hindsight, we look back on the work of Jones, Osborne, and Mendel. The conference of September 1905 had set the Station on the road to both the biochemistry and the genetics of corn. By 1913 Osborne had completed the work on biochemistry, but it took five more years to complete the work on genetics. Remember, however, that while Osborne and Mendel could turn their experiments over in the few weeks of the generation time of rats, the geneticists needed a full year for each generation of corn.

One of the puzzles of this story is why Osborne and Mendel didn't say to Jones, or Jones say to Osborne and Mendel, "There must be a gene spotted somewhere along a corn chromosome that controls the synthesis of lysine. Let us go for it." They didn't go for it, but (as we said in Chapter 6) Oliver Nelson, Jones's former graduate student technician, did go for it with a biochemist at Purdue named Edwin Mertz.

THE END OF THE SAGA OF CORN AT THE STATION

And thus ends this portion of the saga of corn improvement. In 1905, the research effort at the Station was split in two – East to study the genetics of corn, Osborne to study its biochemistry. Their research came together again, a thousand miles away and nearly 60 years later, in the minds of two young scientists in Indiana. The conference of September 1905 led to results that are hard to believe.

It opened the road to hybrid corn, now planted on *eighty-four million acres* in America (to say nothing of the rest of the world).

It opened the road to male sterile plant breeding and to the discovery of the genes in corn for high lysine and tryptophan.

It opened the road to the discovery of the significance of amino acids and vitamins in human nutrition.

It earned memberships in the prestigious National Academy of Sciences for the botanists East, Jones, Mangelsdorf, and Nelson, and for biochemists, Osborne, Mendel, McCollum, and Mertz.

Jenkins's dream had come true. Science had advanced, and the people and pigs and cows that depend on corn are better nourished than before. Johnson's principle, enunciated long ago in New Haven had paid off. Theory and practice do march well together.

Osborne continued protein research until he retired in 1928. He died in 1929.

H. B. VICKERY APPOINTED HEAD

In 1928 H. B. Vickery became department chief. Vickery was a native of Nova Scotia, but with New England antecedents: his loyalist ancestors fled Connecticut for Nova Scotia during the Revolution. He graduated from Dalhousie University in Halifax in 1915 and, in the fall of 1920, came to Yale to do graduate work in chemistry under Treat B. Johnson. On Johnson's recommendation, he went to work for Osborne in early 1921, becoming one of the many students whose graduate work has been subsidized by the Station. Yale granted him his doctorate in 1922 and an honorary Dsc in 1948.

Clearly, young Vickery decided early not to try to climb Osborne's ladder to distinction in science. He concentrated on organic acids in leaves rather than amino acids in seeds. Since tobacco has a large leaf, he chose it as his chief experimental organism, probably spurred by a little nudge from Director Slate. With George Pucher and other colleagues, he published a series of twenty papers which carried the generic title of *The Metabolism of Organic Acids of*

Tobacco Leaves. Number I, "A Preliminary Study of the Non-Volatile Organic Acids of Tobacco Leaves," was published in 1930. Numbers XIX and XX were published in 1963, the year he retired. The series included papers on the acidic changes in the leaf during growth, curing, and fermentation.

Where Osborne published only one Station bulletin, Vickery published thirteen. He published also in *The Frontiers of Plant Science*. Cereal chemists recognized Osborne's work on cereal proteins by establishing the Osborne gold medal and giving the first one to Osborne himself. Similarly, tobacco industry chemists awarded Vickery a bronze plaque for his work on curing tobacco. As Vickery approached the end of his career, the editors of the *Annual Review of Plant Physiology* asked him to write a story of his life. He entitled it *A Chemist Among Plants*.

In World War II, a need arose for blood albumin, which could be produced by fractionating blood serum. During 1942 and much of 1943, Vickery traveled to Harvard several days a week to supervise the production of blood albumin. One of the most exciting episodes in Vickery's life was traveling to the Pacific in 1946 to witness the explosion of the third atomic bomb.

THE DEPARTMENT TURNS TO ENZYMOLOGY

The Department changed direction again in 1952. Osborne had opened biochemistry at the Station in the classic descriptive phase, purifying and describing the proteins and amino acids in numerous seeds. He moved next to the function phase. How nutritious were the proteins and amino acids in seeds? Interestingly, he used edestin from marijuana seeds as a check, and complained when eventually the law stepped in and prohibited the sale of marijuana.

In order to learn how plants make and use organic acids, the department needed expertise in enzymology. Vickery hired a post-doctoral student, Israel Zelitch, from Ochoa's laboratory at New York University School of Medicine. As he had earned his PhD at Burris's laboratory in Wisconsin, Zelitch, in coming to the Station, reversed H. P. Armsby's trip to Wisconsin a half century earlier. Armsby had taken Connecticut know-how to Wisconsin; Zelitch brought Wisconsin know-how back to Connecticut.

GLYCOLIC ACID AND PHOTORESPIRATION

Zelitch was interested in glycolic acid, a leaf compound involved in photosynthesis. In 1955, it occurred to him to study its role by inhibiting the enzyme glycolic acid oxidase with a sulfonic acid analogue. During a hot spell in the summer of 1960, he sprayed the analogue onto some tobacco leaves in the greenhouse. The next day he made a serendipitous discovery. The leaves on the check plants were wilted in the middle of the hot day, but the leaves on the treated plants were not. In the annual report for that year he asked whether "the metabolism of glycolic acid is in some way associated with the physiology of the stomates?"

In checking this out, he discovered that glycolic acid is needed to open the stomates. This suggested that chemicals might be used to reduce water loss during a drought. Later, he and Waggoner, working in a forest, showed this to be possible; they also showed that the savings in water was greater than the loss of photosynthate.

In 1965, Sawhney and Zelitch demonstrated that potassium accumulation in the guard cells of leaves is directly related to the opening of the stomates in light. Their paper has been cited so often that *Current Contents* has awarded it a "Citation Classic."

During these researches Zelitch discovered the role of glycolic acid in photorespiration. Strangely, some plants produce CO_2 at the same time they are taking in CO_2 from the outside air. This is called photorespiration. Elsewhere it was shown that a three-carbon compound is the first compound produced in photosynthesis. In other plants, the first product is a four-carbon compound.

In general, three-carbon plants indulge in photorespiration: they produce CO_2 in the light. Four-carbon plants, however, do not indulge in photorespiration, hence their production of carbohydrate is higher than that of three-carbon plants. The classic species used to illustrate this point are corn and wheat. Corn is a four-carbon species and produces high yields. Wheat is a three-carbon species and produces lower yields than corn.

"A plant," as the old saying goes, "is caught between a rock and a hard place." For photosynthesis, it has stomates in the leaf surface as gates to let the CO_2 in and O_2 out. It pays a price for this, however: water passes out with the O_2. If it loses too much water, the plant dies. To prevent this, the plant closes its stomates or even wilts. To collect enough CO_2, the plant produces a huge area of leaves, about six to eight acres of foliage for each acre of land.

This presents another problem for the plant. To protect itself from losing water through its leaf surface, a plant must cover itself with an excretion of a thick waxy substance, called the cuticle. In 1965, Kolattukudy joined the staff and made considerable progress in understanding how the plant manufactures this unusual substance.

OTHER DISCOVERIES IN BIOCHEMISTRY

Over the years the department made many other discoveries of the biochemistry of plant growth.

1935. Pucher and Vickery developed a method for determining glutamine and asparagine that was widely used in biochemical analyses.

1942. Pucher and Vickery identified "crassulacean malic acid" as isocitric acid, helping elucidate the citric acid cycle.

1942. War cut off the European source of asparagine that was widely used in biochemistry. Vickery discovered that a white lupine native to Florida is a good source of asparagine.

1947. Vickery devised a rational system for the nomenclature of amino acids and related compounds.

1955. Palmer, in a beautiful piece of research, cut the drudgery of organic acid analysis by using ion exchange chromatography.

1963. Hanson and Rose used a stereochemical method to show how plants synthesize citric acid.

1966. Hanson introduced the concept of prochiralty and invented a system to describe the stereochemistry of enzymatic reactions. This is widely used in biochemistry research.

1970. Hanson and Havir showed that a dehydroalanyl residue is part of the prosthetic group of the enzyme phenylalanine ammonia-lyase, and thereby discovered a novel enzymatic mechanism.

Historical Markers along the Organizational Road

1847. J. P. Norton studied proteins in the oat seed.
1882. First Station building erected. Devoted to chemistry.
1888. Director Johnson assigned Osborne to protein research.
1905. Biochemistry moved into newly built Johnson Laboratory. First building converted to a library.
1909. L. B. Mendel became an unpaid staffer. East Wing added to Johnson Laboratory.
1911. Johnson Laboratory burned and rebuilt.
1928. Osborne retired. Vickery was promoted to head of department.
1930. Mendel finally made a member of the paid staff.
1963. Vickery retired. Zelitch was promoted to head of department.
1975. The Station reached its centennial.

The Professional Staff

Regular Staff

H. P. Armsby	1877-1883
T. B. Osborne	1888-1928
C. G. Vorhees	1890-1891
I. Harris	1901-1905
Edna L. Ferry	1909-1919
A. J. Wakeman	1912-1948
H. B. Vickery	1921-1963
A. C. Chibnall	1922-1924
Helen Canon	1925-1930
G. W. Pucher	1928-1947
L. B. Mendel	1930-1935
C. A. Cook	1931
Rebecca Hubbell	1936-1954
C. W . Partridge	1948-1949
S. A. Hargreaves	1949-1951
A. N. Meiss	1949-1951
I. Zelitch	1952-Date
J. K. Palmer	1953-1956
D. G. Wilson	1953-1956
L. Hankin	1953-Date
C. C. Levy	1957-1960
G. A. Barber	1957-1959
K. P. Hanson	1960-Date
D. A. Walker	1962-Visitor
Evelyn A. Havir	1964-Date
P. E. Kolattukudy	1964-1969
P. P. Poincelot	1970-1977

Post Doctoral Staff

R. J. Block	1929-1932
J. Melville	1932
H. E. Clark	1934-1936
E. L. Smith	1941-1942
Jane K. Winternitz	1941-1942
Evelyn A. Havir	1953-1964
A .O. Klein	1961-1962

Graduate Students

H. P. Armsby	1877-1881
H. P. Vickery	1921-1923
C. G. Vinson	1925

Entomology

There's the termite that found some wood
Tasted it and found it good
And that is why your cousin May
Fell through the parlor floor today

Insects, being animal, visible, and pestiferous, have played a role in the history of plagues, pestilence, and famine. The Bible tells us how locusts (actually grasshoppers) ate farmers' crops and created famine. Succeeding pages will attempt to give a history of these fascinating organisms and their impact on the sociology of Connecticut during the two centuries from the arrival of the Hessian fly, *circa* 1775, to the centennial of the Experiment Station in 1975.

Even though the major part of the work on entomology at the Experiment Station deals with plants, it is interesting that the researchers must deal also with fleas, cockroaches, mosquitoes, termites, and even with ticks that, of course, are not insects.

Economic entomology is one way of dealing with our society's deep-seated bug phobia. This chapter will describe the Station's efforts in this area. As in other chapters in this book, entomology must be traced as far back as possible in Connecticut history.

This is not the only history of Connecticut entomology, however. On the occasion of its twenty-fifth anniversary, The Connecticut Entomological Society published a series of memoirs, four of which were historical. Some more notes on history were published by Britton in Station Bulletin 327 in 1931. These have all been helpful. Neely Turner and John Anderson provided much help in preparing this history.

THE BUG MENACE

In our folklore insects were equated with devils. The Wassons, man and wife, have published two beautiful tomes on the folklore of mushrooms. In a paragraph on insects in folklore, they state:

> bugs, flies, moths ... in short the insect world constituted for our ancestors until recent times an order of nature with supernatural powers, mostly malevolent and always awesome.... [T]he fly was demonic ... [;] the neighbors of the Israelites in the old testament worshipped Beelzebub whose name meant the 'Lord of the Flies....' In England the word 'bug' until the seventeenth century meant an evil spirit ... [;] then the word came to designate a creeping insect.

The word "bug" still carries unpleasant connotations in our language. "Get the bugs out of that badly running car." "Your hotel room in Russia is bugged." We use the derivative word, *bogey*. Combat pilots in World War II would warn of a bogey at three o'clock. We speak of a bug house and a bugaboo.

The Station has tried all the remedies in the book to stop epidemics of insects and thus to mitigate the bug threat: nursery inspection to reduce spread of insects, eradication (kill them out), removal by hand (pick them off), encouragement of their enemies, and use of chemicals to kill them.

ENTOMOLOGY BEFORE THE STATION

The Hessian fly offers a good starting point for this chapter. It was a fearsome insect that, about 1775, crossed the ocean with the mercenary Hessians who had been hired by King George to help beat the upstart, revolutionary Americans into submission. The Hessians brought along their horses and wheat straw to bed them down. The Hessian flies came riding along in the wheat straw. In modern terms this action would be called "biological warfare," because within a very few years, the Hessian fly had driven wheat out of Connecticut. With the decline of the Hessian Fly, however, wheat can now be grown in Connecticut again.

TAXONOMIC ENTOMOLOGY

Most entomology prior to the establishment of the Station was taxonomic. In Britton's treatment of pre-station history, he complained about the paucity of records, saying that most of the records were about taxonomy. The first taxonomic paper he found was published by Dr. Thaddeus W. Harris, librarian of Harvard University, who published on beetles in the *Transactions of the Hartford Natural History Society*, Vol. l, p. 365, in 1836. Britton writes, "He is now known as the father of economic entomology in Connecticut."

Britton lists twelve other taxonomic entomologists who worked in Connecticut before the establishment of the Station. One of these was Noyes Darling, onetime mayor of New Haven. Darling is discussed more extensively in the chapter on plant pathology.

ECONOMIC ENTOMOLOGY

A few fragments of economic entomology in the last century were published by B. H. Walden in the proceedings of the Connecticut State Board of Agriculture. The earliest work cited is that of Joseph Barratt, MD, in the 1854 *Transactions of the Connecticut Agricultural Society*, the forerunner of the State Board of Agriculture. Barratt mentioned *Selandria cerasi*, plant lice, canker worms, and magpie caterpillars. Barratt even went into ecology, noting that the summers of 1844 and 1845 were extremely hot and dry and favorable to insects. In the very wet summer of 1846, however, canker worms on apples and magpie caterpillars on gooseberries were "enfeebled and diseased."

The 1866 report of the State Board of Agriculture finds notes on canker worms, plum curculio, peach borers, Hessian fly, and thrips on grapes. In later years other destructive insects were listed: grasshoppers, asparagus beetles, potato bugs, and apple borers.

FIRST ENTOMOLOGY AT THE STATION

In 1888, Thaxter, who arrived at the Station to set up a department of botany had been interested in insects from his work at Harvard. He was followed by Sturgis, who, in turn, was joined in 1893 by the horticulturist W. F. Britton. In 1894, Sturgis found a dangerous new insect in Connecticut: the San Jose Scale, which sucked the juice out of apple shoots. As Thaxter and Sturgis were plant doctors, they were perforce asked for information about destructive insects.

THE BUG MENACE IN THE GENERAL ASSEMBLY

The San Jose Scale which invaded Connecticut was traced to a nursery in New Jersey. This raised the question of nursery inspection as a device to limit the spread of these pesky insects. Britton was climbing the ladder. Here was a good lift up. After a little judicious lobbying in 1901, the legislature created the post of State Entomologist at the Station, and Britton was on his way to try to keep Beelzebub out of Connecticut. In 1903, the legislature gave him the funds and authority he needed. He was told to inspect any premises he thought might be infested with insects and to order the plants destroyed. Turner, in his Memoir, discussed many other cases of legislative effort to deal with the bug menace.

THE GYPSY MOTH MENACE

The gypsy moth is probably the best example of the effects of the bug menace in Connecticut. This has been discussed by Hitchcock in the Memoirs of the Entomological Society. This voracious devourer of forests was first found in Eastern Connecticut in 1906. Mr. Earnest Frensch, an amateur lepidopterist of Mystic, wrote Britton in February, 1906, "probably it will be new to you that *Porthetria dispar* has reached the town of Stonington." Britton was no slouch. Here was his chance to do battle with Beelzebub. He hurried down to Mystic to confer with Mr. Frensch. Undoubtedly he had to go by train. He rushed back home to print two thousand

cards with a portrait of a gypsy moth for distribution to citizens who were asked to look for the insect.

In 1907, the Legislature appropriated funds to the State Entomologist to extirpate the gypsy moth. For some reason not now clear, the appropriations for the Office of the State Entomologist were sent directly to Britton, who deposited them in a State Entomologist's account in a local bank and issued checks in payment of both salaries and expenses of the work. This must have caused the Director many headaches. I am not certain when this practice was discontinued.

L. O. Howard of the USDA tried to get into the act by offering to pay some of the costs of eradicating the gypsy moth, but Britton refused, saying that Connecticut could take care of its own problems.

Britton used his new authority to hire a helper who found and destroyed thirty egg masses that first year. By May, the helper had found many more egg masses, most of which had hatched. By searching the foliage, however, he found and killed ten thousand caterpillars. He must have done a pretty good job, because during the next year he could find only three thousand caterpillars. Year by year the number of caterpillars declined until 1911, when none was found in the New London area. Britton must have been pleased. Beelzebub was gone.

The satisfaction of extirpating Beelzebub from Connecticut was short-lived, however. In 1909, he showed up in Wallingford, fifty miles to the west. "Every effort will be made," wrote Britton, "to exterminate the gypsy moth colony in Wallingford." By 1913 no more gypsy moths could be found in Wallingford. Britton had scored again.

But the gypsy moth was persistent. The very next year, it was to be found in ten eastern towns, and by 1916 in twenty-two towns. This general spread was later attributed to blowing of the larvae by gale force winds. By 1922 Britton began losing hope that he could really keep Beelzebub permanently out of Connecticut. Sadly, he asked, "Must the State continue ... to wage what seems to be a losing battle against the gipsy [sic] moth?"

THE SOCIOLOGY OF THE GYPSY MOTH MENACE

The gypsy moth has surely had a strong impact on our society. It was responsible for the great environmental movement set off by Rachel Carson's famous book, *Silent Spring*. The Station played a small role in this great movement.

In the early part of the century, Britton sprayed infested forests with lead arsenate from the ground, treated egg masses with creosote, and scorched them with torches. Like the phoenix, however, the insects rose again from the ashes. For many years prior to 1950, gypsy moth damage was negligible, but this was only the lull before the storm. The caterpillars defoliated two hundred acres in 1951, but two years later (1953) the damage rose to two thousand acres and then exploded to fourteen thousand acres in 1954. The intensity of the bug menace and the pressure on the Experiment Station increased accordingly.

Responding to the mandate from the citizens to "do something," Friend, the State Entomologist at the time, opted to apply DDT from the air. In those days everybody loved DDT. It had saved our soldiers from malaria in the South Pacific. Just after the war, it had scotched a severe epidemic of typhus fever in Italy. And Muller, its discoverer, had won a Nobel Prize.

Yet this was troubling. Here was a poison, however beneficent, falling from heaven on babies in their back yard playpens. The bug menace and the poison menace were on a collision course. As the 1950's wore along, both gypsy moths and DDT spraying grew. People whose forests were not damaged greatly outnumbered those whose forests were. Hence, they could exert more political pressure to abandon spraying and let nature take its course.

In 1955 the U.S. Department of Agriculture set out to use DDT to "eradicate" the gypsy moth from America, and found it easy to persuade Congress to provide the money. They tried out the idea by spraying Cape Cod with DDT from the air. Assuming success, they decided to start at the western edge of the infestation and shove the gypsy moth into the Atlantic Ocean. In 1957 they sprayed DDT all over New Jersey, Westchester County (adjacent to New York City), and Long Island. Despite strong local objections, USDA ignored the poison menace as well as the rising antispray pressure from conservationists (soon to be called environmentalists). They flew right over their objections, their houses, and gardens, spraying DDT as they went. The citizens watched the spray streaming down from the bellies of the planes, but had no place to hide. They took their anger to court, but lost.

Thinking that winning the court case on Long Island had vindicated them, in late 1957 the USDA proposed to continue the "eradication" of gypsy moths by spraying the whole state of Connecticut with DDT from the air. By law, however, they had to obtain the permission of the Experiment Station. In the meantime the Station found itself in the eye of the storm swirling around the conflict between two menaces, as evidenced by a prophetic statement in the Station Report for 1960: "The Station received more protests over the use of pesticides than in any previous year." This explains why Turner, State Entomologist at the time, with the concurrence of the Director and the Board of Control, said, "No," to the USDA and pesticides. Mind, this was four years before Carson's book.

The Hartford Courant, hearing of Turner's refusal, wrote an editorial entitled "Gypsy Moths And States' Rights" on January 14, 1958, congratulating him. It said, in part:

> Some of our readers in the South may be reassured by Connecticut's strong stand for states' rights in the mild controversy now going on between our State Entomologist, Neely Turner, and the representatives of federal authority. The subject is eradication of gypsy moths. Last year the Federal Government practically ordered Mr. Turner to spray the whole 3,000,000 acres of the State for gypsy moths, even though 2,000,000 acres are moth free. Mr. Turner stood firmly on his right to spray only where needed and the Federal forces retreated in temporary confusion. Now they are beginning to make overtures again, but Mr. Turner is firm.
>
> Mr. Turner is right. If necessary, let us call out the [Governor's] Foot Guard and the Horse Guard to repel further forays by federal authority, even if it comes armed with DDT.

Four years later, in 1962, Rachel Carson wrote a book in which she devastated entomologists as stone age scientists under the domination of the chemical companies. Although she lived just across Long Island Sound, she ignored the stand on spraying taken in 1957 and 1958 by Connecticut State Entomologists. Contending that DDT had killed and silenced the birds, she entitled her book *Silent Spring*. It earned her a vast amount of money. In the spring of 1962, President Kennedy asked his science advisor to set up a committee to confer with her. I was flattered to be a member. We wrote a report on our conference.

Rachel Carson converted "pesticide" into a dirty word and created a whole new class of people, the chemophobes, who see a carcinogenic chemical under every stone on the roadside. Her book was the stimulus for the powerful environmental movement that sweeps us along these days. Advertising copywriters surely enjoy something new to add to labels on consumer products: "This product contains only natural ingredients, no chemical additives."

CONTROLLING PESTS WITHOUT PESTICIDES

The Station entomologists are proud to say to the Rachel Carsons that they have always searched for methods other than chemicals to fight the bug menace. They have tried hard over the years to make use of the truism that "Big bugs have little bugs on their backs to bite 'em, and these bugs have smaller bugs, and so on, *ad infinitum*."

Britton recognized this, even as an undergraduate at the University of New Hampshire. His graduation essay envisioned a time when entomologists would rear parasites in the laboratory and release them on farms to control pests. When he came to the Station in 1894, he found a kindred soul in Thaxter, who had killed a fat in 1894, he found a kindred soul in Thaxter, who had killed a fat tomato worm by caging it with a fungus-infected leaf hopper. The fungus, named *Empusa*, was called at that time an obligate parasite because it could not be grown in artificial culture (as *Penicillium* is grown to produce penicillin). Later research has shown that *Empusa* can be grown that way.

Following is a list of efforts to control the bug menace without poisons.

1898. Britton established the first nursery inspection.

1900. Britton one of the first to use sticky bands around trees to control canker worms.

1901. Legislature created the post of State Entomologist. Britton first incumbent.

1902. Britton wrote: "Twenty years ago I went through the orchard with a brush on a pole to remove tent caterpillars." He designed and manufactured a brush which would be in common use for years. The same year, Britton spoke of "natural enemies of the San Jose Scale."

1903. In Westville, Britton found an egg cluster (probably from imported nursery stock) of a praying mantis, which eats other insects. He obtained 40 egg clusters from Philadelphia and released them in several locations. The praying mantis is the State Insect of Connecticut, but it does not seem to have helped the State Entomologist to control damaging insects.

1904. Britton and Viereck advocated draining and filling of marshes rather than insecticides to control mosquitoes.

1907. Britton used tar paper discs to control cabbage maggot.

1908. Britton advocated draining Beaver Swamp in New Haven to control a malaria epidemic in that section of the city. This was done with excellent results. This is now Beaver Park.

1908. Clinton went to Harvard to work with Thaxter for a couple of months to try to tame the fungus, *Empusa*, to make it work in practice to control insects. He could not.

1909. Clinton went to Japan in search of parasites of the gypsy moth. Though he found some, they were ineffective in Connecticut.

1918. Britton worked on parasites of the potato beetle.

1919. The brown tail moth entered Connecticut forests in 1910, but was gone by 1919, presumably eradicated by introduced parasites.

1926. The Japanese beetle invaded Connecticut. Beelzebub won again. It was a very destructive pest. City people looked on in dismay as the grubs ate the roots of their lawn grasses and the beetles ate the petals off their roses. In the 'forties someone at the New Jersey Station discovered a bacterial disease of the beetle, called "the milky disease," that could be grown commercially in culture on beetle grubs. It produces spores that can be dried, mixed with powder, and spread over infested lawns. The Station entomologists were delighted, because poison could be abandoned. Lawns were no longer damaged. Miss Carson paid no attention to this victory over poisons to kill Beelzebub.

I am sad to say, however, that by now (1990) the beetles have developed resistance to the disease (as they would have developed resistance to DDT had it been used on the lawns). The beetles are back again to eating the roots of our lawn grasses and the petals of our roses. Beelzebub is persistent. In any event, this is an elegant example of how city people can use agricultural research as they grow their plants.

1927. Britton reported "work toward developing a substitute for arsenical sprays" – 34 years before Carson's diatribe against poison-oriented entomologists. In that year, Britton and his colleagues set out to develop techniques for raising insect parasites like *Trichogramma minutum,* one of the first such efforts. On a scientific mission to Russia in 1974, I found the Russians raising *Trichogramma* in several locations.

1929. Apparently, the research on *Trichogramma* began to pay off for, according to the 1929 report, the Station had built equipment for raising *Trichogramma* in quantity. Schread produced them on grain moth eggs.

1930. The Station released six million *Trichogramma* infested grain moth eggs to 140 growers. This seemed to have dramatic results, for in that year, the fruit moth destroyed only ten percent of the fruit, in contrast to eighty percent a year earlier. Britton did suggest, however, that the dry summer of 1930 helped out.

1932. The Station's output of *Trichogramma* grew rapidly, 23 million in 1932, for example, and 28 million in 1933. When the boiler house was expanded in the late 'thirties, it contained several air-conditioned rooms for raising *Trichogramma*. The work continued during the war years.

1938. The Station tested the effectiveness of *Trichogramma* by setting traps for wild *Trichogramma* in four separate orchards, using large quantities of grain moth eggs as bait. Astonishingly, however, fewer parasites were trapped in orchards where *Trichogramma* had been released than in the check orchards. Beard thought Trichogramma produced in the small grain moth eggs were too small to be effective in the field. In any event, with the arrival of DDT and other organic insecticides, breeding of *Trichogramma* faded.

Here is the earliest example of our dealing with the political aspects of the poison menace. In 1950, when the State Highway Department built an extension of the Wilbur Cross Parkway past Meriden to connect with U.S. Route 5, landscaping shrubs bought in Central New York State were planted. With them, a new pest was introduced, the European chafer. At the insistence of the USDA the Station treated the nearby countryside with dieldrin, but the chafers continued to expand in the infested area, eventually reaching a nursery, whereupon the USDA proposed to spray dieldrin by air over the whole area including the city of Meriden. Turner, State Entomologist said, "No," whereupon the federal bureaucrats applied pressure to the Mayor of Meriden, threatening to lay down a tight quarantine around the nursery. This would have effectively put the nursery out of business. The Mayor wrote to me, requesting my approval, as director, of the spraying.

I wrote in reply: first, that dieldrin was a pretty poisonous substance; second, that it would fall on babies and children playing outdoors; third, that it would fall on any cat caught out of doors; fourth, that the cat would lick the dieldrin from its fur and poison itself; and finally, that if the Mayor would sign a letter to me and say, "Let us spray," I would approve. I never heard from the Mayor.

QUARANTINE

Quarantine was a popular way for economic entomologists to control a new invasion by Beelzebub. It was not very effective for gypsy moths, as shown above. The European corn borer is another example. When this insect appeared in Connecticut in 1923, Britton established a quarantine. The 1930 Station report says that quarantiners stopped 3,452,439 (count 'em!) automobiles. The motorists were surely unhappy with the Experiment Station, and I suspect the corn borer moths laughed as they flew westward over the stalled road traffic below. The next year's report says the quarantine was removed; the corn borers must have laughed again.

Historical Markers along the Organizational Road

1894. Britton appointed "Horticulturist."

1901. Entomology department established. Britton as head.

1902. Walden appointed as first assistant.

1903. Walden published index to insects in early entomology.

1907. Legislature passed the first of several gypsy moth laws and made first appropriation of $2500 for gypsy moth control.

1919. Phillip Garman appointed as first research entomologist.

1939. The boiler house was rebuilt and named Britton Building. Britton died and R. B. Friend became head of the department.

1948. An effective item in Governor Bowles's reorganization of State Government was moving mosquito control to the Department of Health.

1957. Second edition of *Plant Pest Handbook* published.

1959. Friend retired. Turner became head of the Department.

1962. Rachel Carson's book, *Silent Spring,* castigated all entomologists.

1968. Turner retired. Anderson became head. *The New Haven Register* devoted its "November Salute" to Turner. It said that "Turner saw the potential hazards of the random use of pesticides long before the late Rachel Carson brought the question into international prominence."

The Professional Staff

W. E. Britton	1894-1939	Diedrich Bodenstein	1944-1945
B. H. Walden	1902-1945	James B. Kring	1951-1976
H. L. Viereck	1903-1905	George Plumb	1933-1952
Donald J. Caffrey	1910-1913	John C. Schread	1929-1972
A. B. Champlain	1910-1913	David E. Leonard	1957-1970
Quincy B. Laury	1913-1918	John Anderson	1964-1977
Max P. Zappe	1914-1954	C. C. Doane	1956-1977
Phillip Garman	1919-1960	Calvin Lang	1954-1955
Roger B. Friend	1924-1958	Richard Quinton	1955-1962
Neely Turner	1927-1968	Robert C. Wallis	1953-1963
J. Peter Johnson	1926-1968	S. W. Hitchcock	1958-1972
Samuel T. Sealy	1920-1923	Ronald J. Prokopy	1964-1968
Robert C. Botsford	1923-1950	Richard C. Moore	1968-1976
Raymond Beard	1943-1948	George Schuessler	1968-1989
D. E. Greenwood	1943-1948	Ronald M. Weseloh	1970
W. T. Brigham	1929-1969	Dennis Dunbar	1970-1977
B. J. Kaston	1935-1939	James T. Sheldahl	1972-1975
Carl Parsons	1946-1948	J. Granett	1971-1976
Robert Staples	1948-1949	H. K. Kaya	1971-1977
Charles Remington	1949-1953	Marjorie Hoy	1973-1974

Visiting Scientists from Abroad

Charles Potter	England	1947
Andrew MacIntosh	England	1950
Geoffrey A. Wheatley	England	1953
Douglas Waterhouse	Australia	1956
Leonard Broadbent	England	1955
Mary Franklin	England	1955

Roland Thaxter's Laboratory

It was built for him in 1888 with Hatch Act Funds.
Thaxter called it *Mycotheca*, or "Fungus House."

9

Plant Pathology

This chapter in the general history of The Connecticut Agricultural Experiment Station will treat plant pathology, from the time the legislature passed the barberry eradication law in 1725.

DISEASE BEFORE THE EXPERIMENT STATION

Two hundred and fifty years ago the farmers of Connecticut convinced the legislature that barberries cause wheat rust and persuaded it to pass a law declaring the barberry a public nuisance that must be eradicated. For centuries before deBary explained it in 1853, farmers had been telling the intellectuals that barberries bring on wheat rust; but they were ignored as yokels. In those days, the intellectuals said that rust on the wheat leaves is an excrescence pushed out from a sick plant.

This is an interesting sociological case. The farmers had more votes than the intellectuals and, hence, the legislators listened to them rather to the intellectuals. Of course, barberries could not be eradicated and wheat rust still abounds; Americans were still "eradicating" barberries well into the twentieth century, two hundred years later. The nation did not learn and spent millions "eradicating" *Ribes* bushes to control white pine blister rust, and still more millions "eradicating" chestnut blight and Dutch elm disease. All four diseases are still with us.

It is a striking coincidence that St. Anthony's Fire (ergotism) should be next in line after wheat rust in the chronology of events in Connecticut plant pathology. A few years ago a neighbor lent me a copy of a small-town newspaper printed in Litchfield, Connecticut, in 1832. It contains an advertisement for Dr. Relf's "Botanical Drops" as a cure for St. Anthony's Fire, presumably caused by a contamination of ergot in the rye being offered for sale in the adjoining column. When wheat yields are reduced significantly by rust, people turn to rye. Unfortunately, the same weather that encourages wheat rust also encourages ergot to develop in rye. When people eat such rye, they suffer from St. Anthony's Fire.

Two separate authors writing in *Science* magazine recently, concluded from studying colonial records in Salem, Massachusetts, for the 1690s that those accused of being witches were instead victims of St. Anthony's Fire. The case would be considerably stronger if someone could find that the rye was infected with the ergot disease in that period.

Twelve years after the Litchfield case, Connecticut pioneered again. In December 1844, Noyes Darling, a New Haven lawyer and farmer, published in the *Albany Cultivator* an astonishingly prescient paper, "The Yellows Disease of Peach Trees," on what would later be considered a virus disease and still later a mycoplasmal disease. Like the lawyer he was, he assembled all the bits of evidence available to him and concluded: first, that since the disease could be transmitted by grafting, it must be due to a poison (all viruses were called poisons to begin with); second, since the disease spreads from tree to tree and from area to area, something must move it; and, third, that this something must be an insect. This was ten years before Pasteur and deBary showed that disease is caused by living entities, and a half century before Waite proved insect transmission of disease.

Then Darling went further and concluded that it should be possible to combat the poison "if diseased peach trees should be made to absorb a variety of matters ... that will ... decompose the poison." A century later, Stoddard, also in New Haven, showed that X-disease of peach could be controlled by injecting the peach tree with sulfanilamide.

THE FIRST UNIVERSITY LECTURE

During the first week of Yale's Lectures on Agriculture in 1860, the Reverend Chauncy Goodrich delivered the first university lecture on vegetable pathology. As far as I know, Goodrich was the first person in America to use the word pathology in connection with plants. He lectured on the late blight of potato. He was not as shrewd as Darling was sixteen years earlier. He thought the disease was due to the "facility with which a weakened cellular structure will pass into fermentation in the presence of albuminous matters." He surely knew how to hide his ignorance.

THE FIRST REPORT BY A BIOLOGIST

Plant pathology appears next in Connecticut in 1867 when Professor W. H. Brewer, biologist at Yale, read a paper before the Connecticut State Board of Agriculture entitled "On the Plant Diseases Caused By Fungi." He spoke of spurred rye, or ergot, potato rot, wheat rust, corn smut, onion smut, plum black knot, apple rust, peach curl, American grape mildew, lettuce mildew, and raspberry rust. It is interesting that ergot was first on his list, and that apple scab was missing.

In speaking of these diseases, he said, "The main chemical fact is that they [the fungi] are the cause and not the result of disease." He was probably first in America to recommend a chemical control for a plant disease. He recommended sulfur for powdery mildew of grape. Presumably he knew of Tucker's work in Europe.

THE FIRST "TEXT" IN PLANT PATHOLOGY

Plant Pathology appeared next in Connecticut in a paper entitled *Fungi Injurious To Vegetation With Remedies*, by Byron D. Halsted, delivered at the 1882 meeting of the Board of Agriculture. This might be considered the first text on plant pathology in America. Halsted had only recently been granted the first PhD given by Farlow at Harvard.

About the potato rot he wrote: "There is probably no disease of cultivated plants that has caused so much suffering to the human family as the 'wet rot' in potatoes." The disease occurred in its most virulent form in 1842 and again in 1845. (Brewer had mentioned the epidemic of 1845, but did not mention that of 1842.)

THAXTER ARRIVES AT THE STATION

When Hatch funds first became available 1887, Director Johnson recommended to the Board of Control that the Station begin research on plant diseases. The Board appointed Roland Thaxter to the post. Thaxter, a contemporary of Theodore Roosevelt in biological studies at Harvard, had just obtained his PhD under Farlow. Johnson put him to work on onion smut; Thaxter proceeded to work out the life history of the causal fungus and show that the plants are susceptible for only a few days as seedlings. He controlled the disease with sulfur applied to the row with the seeds, developed a machine to apply the sulfur, and demonstrated it to farmers. How's that for a complete study of a disease? According to Kreutzer, Thaxter was the first plant pathologist to control a soil-borne disease with a fungicide. He also straightened out the etiology of potato scab and named the fungus causing downy mildew of lima beans.

By the time he had become ensconced at the Station, Lamson-Scribner had introduced Millardet's fungicide to America. Lamson-Scribner called it Bordeaux mixture. Thaxter took it up immediately, built his first sprayer from his wife's wash boiler, and began to spray plants. In his 1890 report Thaxter wrote that "potato rot and blight destroyed nearly all of the potatoes in the State. It can undoubtedly be controlled in ordinary seasons by the use of the Bordeaux mixture."

In March 1889, just eighteen months after he arrived, he published his classical Bulletin No. 102, *Fungicides*. He worked with Bordeaux mixture because he considered it his duty. "The use of Bordeaux mixture is an innovation in this State." Duty or no, he disliked the mixture immensely. On the occasion of the publication of his bulletin, he vividly described his reaction in a letter to Farlow. "I am glad you appreciate the beauties of my lotion bulletin.

Bordeaux mixture is the vilest compound imaginable, but it would give me intense satisfaction to fly away to lands ... where blight, rust, mildew, mold, scab, scald, and smut are known by bitter tasting names." (You can see why Thaxter referred to plant pathologists as "squirt gun botanists.")

Thaxter was generally unhappy at the Station. Coming from a wealthy Boston family (his mother, Celia, was a well-known author and hostess of salons for writers and artists on Appledore Island), he found it difficult to devote time to solving farmers' problems with plant diseases. Once he wrote to Farlow that there were not enough days in the week, that he could not catch up with his fundamental work even on Sundays. In dozens of letters, he pleaded with Farlow for an opportunity to return to Harvard where he could give "the bucolic constituency a sound ducking in Bordeaux mixture and run away where I can be absolutely impractical or as impractical as I choose." Farlow reminded him that college teaching involves a lot of drudgery, too. Thaxter's strong concern for the theoretical surely helped, however, to set his new department on the road to follow Johnson's dictum that theory and practice must march together. Despite his aversion to useful research, he carried on his share of it.

Thaxter refused to deal with any disease not caused by fungi. His letters to farmers show an interesting case of this. Some of his early letters to farmers were loaded with requests for specimens of a root gall disease of violets. The disease seemed to intrigue him, probably because of the similarity to the galls on cedar due to cedar-apple rust, with which he was working at the time. Upon discovering that the galls were caused by nematodes , he dropped the whole matter like a hot potato; to the later-to-be-famous L. O. Howard, he complained that his "correspondents seem to think that mycological is a long enough word to embrace nearly everything, so I am bothered by biological questions about which I know little."

AND THEN STURGIS

When, in 1891, Thaxter fled back to Harvard and the protection of alma mater's skirt, Director Johnson asked Farlow for another person. Farlow sent him William C. Sturgis, who struggled with the problems of melding the theoretical with the practical. At the end of his first year at the Station, Sturgis wrote to Farlow: "Just now farmer's meetings are the order of the day. I find them highly enjoyable. Thaxter must be deficient in his appreciation of unwitting humor ... not to have enjoyed these pig-headed progressive farmers with their meetings and debates."

While Sturgis was at the Station, he made several contributions to science and to plant pathology. Being in a tobacco-growing state, he was the first plant pathologist in America to work on tobacco mosaic, in fact, on any plant virus. He called it by the farmer's name, "calico." He showed that it is not seed-borne, and helped to arrive at the conclusion that it is not caused by a fungus or a bacterium.

He looked into the "pole rot" disease of curing tobacco and demonstrated that it is due to fungi growing in the humid air of the curing barn. From this work he designed a new curing barn with one vertical ventilator in the wall for each row of tobacco being cured in the barn. This sort of barn is still used in Connecticut.

In 1899, presumably following the work of Floyd in Florida, he grew tobacco under a shade tent which made the leaves thin and thus better adapted as wrappers for cigars.

PROBABLE FIRST SPRAY CALENDAR

Sturgis made another important contribution to practical plant pathology. In 1893, he published a "Provisional Spray Calendar" – probably the first, but certainly one of the first in America.

"SPARE THE BORDEAUX AND SPOIL THE POTATOES"

Sturgis followed Thaxter in spraying potatoes with Bordeaux mixture. In 1892, he was the first to notice a strange phenomenon, a "magical effect" of Bordeaux mixture on potatoes. He said that "No *Phytophthora* appeared upon the sprayed or unsprayed potatoes ... the experiment was, therefore, valueless so far as the disease is concerned; It is, nevertheless, instructive ... that Bordeaux ... exercises a marked effect upon potatoes, considerably increasing their vitality and period of growth." To Sturgis, then, goes the credit for the subsequent phrase "Spare the Bordeaux and Spoil the Potatoes." Fifty years had to pass before this "magical" property of Bordeaux mixture was explained.

By 1900 Sturgis had also become soured on his job and wrote Farlow that he "was sick and tired of trying to put money into the pockets of thankless people squirting Bordeaux mixture on their trees and incidentally on myself. It is not a beautiful life, and nine years of it have pretty well sickened me of experimental mycology." In 1902, Sturgis left the Station, became an Episcopal minister, and disappeared from science.

CLINTON TAKES OVER

Upon Sturgis's departure, Johnson went to Farlow a third time for a plant pathologist. This time Farlow sent him G. P. Clinton, who was at heart a taxonomist. He became known as the author of a book on smut fungi and served as third President of the American Phytopathological Society. Even so, he had a more practical inclination than either Thaxter or Sturgis. For instance, he helped organize the Connecticut Vegetable Grower's Association.

He played a role in keeping alive the "magical effect" of Bordeaux mixture on potatoes. In his 1915 report he wrote, "The results with homemade Bordeaux mixture early convinced us that Bordeaux mixture possesses unusual merit for potato spraying." He was surely entranced. He wouldn't let go. 1936, his last year at the Station, was the worst drought year in many decades. Dust blew all the way from Oklahoma and settled on cars in Connecticut. Nevertheless, Clinton wrote, "Even though it was a very dry year without any late blight, again this season potatoes sprayed with Bordeaux mixture produced more than untreated plants."

When Clinton died in 1937, Director Slate asked Stoddard to serve as acting head of the department. He served for two years.

HORSFALL BECOMES NUMBER FOUR

In 1939, Horsfall came from the Geneva Station in New York as the fourth head of the department. He persuaded the Director to change the name from Botany to Plant Pathology and Botany, and to introduce a change in the point of view of the Department. Clinton had contended that botany was a descriptive science. Horsfall aimed to make it a quantitative science. Lord Kelvin had written, in effect, that if you can't measure a phenomenon you can't understand it. The first stage in the changeover was to devise a quantitative measurement of severity of plant disease. This resulted in the Horsfall/Barratt system of grading. The published paper has been cited so frequently as to be listed as a "Citation Classic."

Horsfall attempted next to measure the "magic effect" of Bordeaux mixture on potatoes. An entomologist, Turner, came to the rescue. He said that the effect of Bordeaux mixture was to control insects. We decided to quantify this by examining the three-way interaction among insects, Bordeaux mixture, and yield. We chose a half dozen insecticides of varying ability to control insects, two doses of Bordeaux mixture, and an early potato variety that would be attacked by flea beetles, but not by leaf hoppers. Luckily for us we hit a dry summer and disease was absent. During the season we recorded flea beetle damage. Flea beetle damage was negatively correlated with yield. The Bordeaux mixture plots outyielded the checks as usual, but if we examined yield for equal flea beetle damage, Yield on the Bordeaux plots was down by 39%.

Clearly Bordeaux mixture exerts no magical effect on potato physiology. It simply reduces insect damage. The damage from Bordeaux mixture is less than that from insects.

The development of fungicides was another feature of the department. Zentmyer and Dimond pioneered chemotherapy of plant disease, and the ethylene bisdithiocarbamate family of

fungicides was discovered. These compounds are still used world wide after nearly 50 years. Zentmyer published a significant breakthrough. He showed the biological significance of chelation.

AND THEN DIMOND

In 1948, Horsfall went on to become Director, and Dimond became the Department head. During his regime the emphasis in the department shifted again, this time to plant physiology, especially the physiology of wilt disease. This was motivated by the need to know more about a very famous wilt disease, Dutch elm disease. Dimond published on the physics of water movement through the damaged xylem vessels, on the oxidation of phenols in the diseased vessels to quinones and black pigments. He and his staff did elegant research on the enzymes of the fungus and the host. Rich, Taylor and Tomlinson worked on the ozone-induced weather fleck disease of tobacco, its effect on the host, and its amelioration by anti-ozonate compounds and ethylenebisdithiocarbamate fungicides.

During Dimond's regime, Waggoner made significant developments in the relation of weather to plant disease. He published *Epidem*, the first computer simulation of a plant epidemic. This was followed by *Epimay*, a computer simulation of southern corn leaf blight. He also initiated research into the physics of long distance distribution of fungus spores. For this, he used the apple scab fungus and the blue mold fungus of tobacco.

Lounsberry discovered a new nematode on tobacco.

RICH TAKES OVER

In February 1971 Dimond died of pancreatic cancer, and Rich was made chief of the Department. Rich was probably best known for his research with Tomlinson on weather fleck of tobacco, and its control with dithiocarbamate fungicides.

Very soon 1975 arrived, the Station was a hundred years old, and this story winds down.

Historical Markers Along the Organizational Road

1888. Roland Thaxter established department, called it mycology.

1889. New building for Department, Thaxter called it his *mycotheca* or "fungus box."

1891. Thaxter returned to Harvard; W. P. Sturgis took over.

1893. W. P. Sturgis changed name to Department of Botany.

1902. W. P. Sturgis left to become an Episcopal minister. G. P. Clinton took over.

1909. E. M. Stoddard appointed second professional.

1913. Clinton and Stoddard probably saw hypovirulence in chestnut blight, but did not recognize it.

1919. G. P. Clinton member of first Tree Protection Examining Board.

1925. P. J. Anderson, plant pathologist, came to head Tobacco Substation.

1934. Department moved to newly-built Jenkins Building.

1937. G. P. Clinton died. His biography, list of publications, and portrait appear in *Phytopathology* 28:379-387. 1938. Another biography by Thom and East appeared in a Memoir of the National Academy of Sciences.

1937. E. M. Stoddard appointed acting head of the Department.

1939. J. G. Horsfall appointed head of the department. Changed the name to Department of Plant Pathology and Botany.

1948. J. G. Horsfall became Director. A. E. Dimond took over as head of the Department.

1971. Peter Day brought from France the idea of hypovirulence in 1972.

1972. A. E. Dimond died. S. Rich took over as head of the Department.

The Professional Staff in Plant Pathology

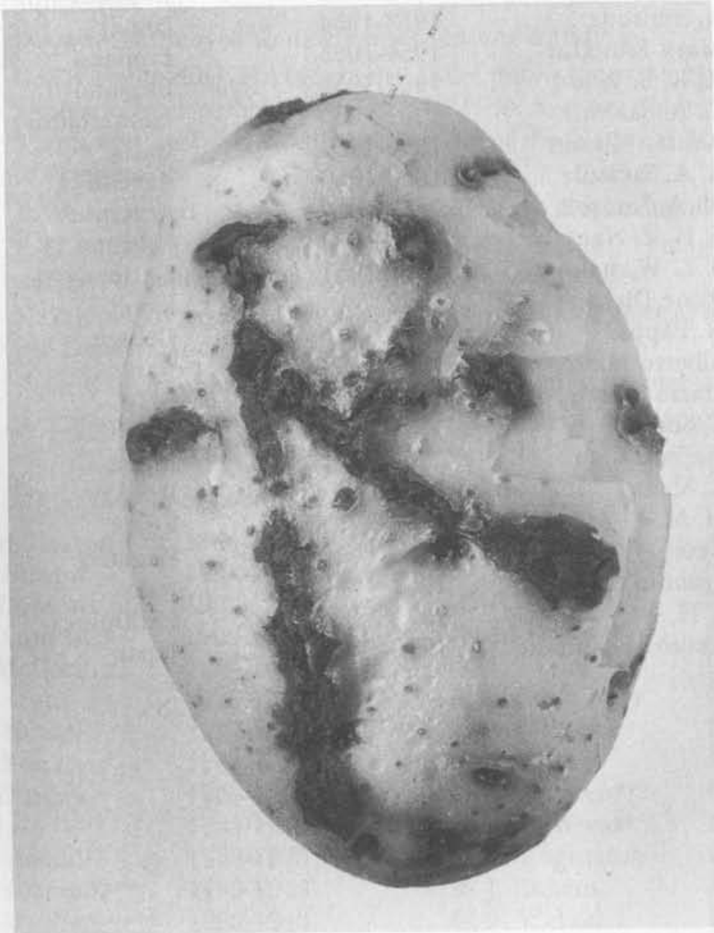
Roland Thaxter	1888-1891	1891 J. P. Hollis	1948-1949
W. C. Sturgis	1891-1902	R. A. Chapman **	1948-1950
G. P. Clinton	1902-1937	W. G. Keyworth*	1950-1951
E. M. Stoddard	1909-1961	David Davis **	1950-1954
F. A. McCormick	1917-1941	G. S. Taylor	1951-1953
W. R. Hunt	1926-1927	B. F. Lounsbury	1951-1953
G. L. Zundel	1927-1928	P. E. Waggoner	1952-1956
H. P. Bender	1928-1930	P. M. Miller	1954-1970
A. A. Dunlap	1930-1937	M. E. Corden**	1955-1958
G. Nutile	1938-1940	R. K. S. Wood*	1956-1957
J. G. Horsfall	1939-1975	L. V. Edgington	1957-1965
E. G. Sharvelle**	1939-1940	R. J. Lukens	1957-1965
J. W. Heuberger**	1939-1943	G. S. Walton	1961-1989
A. E. Dimond**	1940-1972	S. S. Patil	1964-1969
G. A. Zentmyer	1940-1944	H. Tomlinson	1965-1974
G. A. Gries	1942-1945	W. J. Biehn	1967-1973
R. A. Barratt**	1944-1945	David Sands	1970-1976
V. Cochrane	1946-1947	Neal van Alfen	1972-1976
Saul Rich**	1947-1984	J. M. McIntyre	1974-1979

* Overseas visitor, short term

** Fellow, Crop Protection Institute

Visiting Scientists from Abroad

W. G. Keyworth	1950-1951	England
B. G. Peters	1952-1952	England
A. Andrade	1953-1954	Brazil
Mary Franklin	1954-1955	England
R. K. S. Wood	1957-1958	England
G. A. Saaltink	1961-1962	Netherlands
Akhtar Husain	1956-1957	India
A. A. Sarasola	1958-1960	Argentina
M. A. Sarasola	1958-1960	Argentina
S. H. Z. Naqvi	1959-196O	Pakistan
S. E. Wirheim	1961-1962	Germany
Irene Dishon	1962	Israel
N. Pappas	1962	Greece
Alberto Matta	1961-1962	Italy
Mario Salerno	1961-1962	Italy
E. Somers	1963-1964	England
Hajime Kato	1964-1965	Japan
L. M. Lyorkina	1964-1965	Russia
M. M. El-Zayat	1967	Egypt
George Pegg	1958	England
Antonio Graniti	1969	Italy
S. H. Ou	1975	Phillipines
Kasuo Matsumoto	1975	Japan



Potato upon which Roland Thaxter scratched his initials.
Caption reads "RT: A monogram etched in scab by a Boston Brahmin on a lowly Connecticut Potato."

10 Forestry

In this chapter we turn to Forestry and its history in Connecticut and at The Connecticut Agricultural Experiment Station during its century of existence. How does one define Forestry? In this book Forestry shall be defined as the study of trees in the woods as well as trees in the city. Sometimes the latter is called arboriculture.

FORESTRY BEFORE THE STATION WAS ESTABLISHED

The first record of forestry in the State is in 1860 in the famous First Course of Yale Agriculture. During the second week of the course, George B. Emerson, Esq., of Boston gave two lectures entitled "Arboriculture." In the first he said, "As forests have disappeared here, we have an unfavorable change of climate becoming colder in winter and hotter in summer, and the streams become dried up." (Note Waggoner's study a century later on the effect of forest foliage on the hydrologic cycle.)

Emerson introduced his second lecture by saying "that the feeling is common that the farmer's was not a high occupation." He described the role of the nursery in providing seedling trees, and discussed how different trees fill differing niches. "The grandest tree of all," he said, "is the oak and the longest lived. The elm can speak for itself, for it is the only tree that everyone knows." He did well to say this in New Haven, "the Elm City."

FORESTRY IN THE STATE BOARD OF AGRICULTURE

From 1860 to 1876 the record remains deafeningly silent until W. H. Brewer of Yale delivered a lecture before the State Board of Agriculture entitled "Woods and Woodlands." He gave a fascinating account of ancient forestry, citing *A Treatise and Discourse on the Lawes of the Forrest* published by Manwood in 1598. Manwood defined a "forrest" as "a certen Territorie of woody grounds, fruitful pastures, privileged for wild beasts, and foules of Forrest, Chase, and Warren to rest and abide in the safe protection of the King, for his princely delight and pleasure." Brewer went on to say that the officers for protecting the king's woodlands were called foresters, that often they held hereditary office with a name, and that "... of these ancient patronymics, probably the most ancient one which has descended unchanged to the present time is that of duBois."

Brewer discussed the wastage of trees in America and how some thinking citizens had tried to inhibit it by law. He quoted a paper in the *Documentary History of New York*. "At a meeting held on this 29th Day of April, 1699 in Breuklin, Benjamin Vande Water, Jores

Haussen, and Jan Geritse Dorlant were chosen officers to consider the great inconvenience and lose' that the inhabitants of the town suffered because unauthorized persons doe befall and cutt the best trees and sully the best woods."

Brewer made another significant statement: "During the first half century of our national independence, the agricultural importance of the State was greater relatively than now, when railways have placed the fertile West in active competition with our less generous soil and much land that paid well as agricultural land 40 years ago [1836] is now of relatively less value and I verily believe that we have much land in the State which would be three, four, or even five times more valuable as timber land than it is now as nominal 'cleared' land or 'improved land.'" If Professor Brewer were alive today, he would see that his recommendation has been followed. The poor land of the State has gone back to woods.

In 1877, the Legislature passed an act exempting tree plantations from taxes for a ten-year period. In that year, the State Board of Agriculture printed one lecture entitled "Forestry Notes" by James H. Bowditch, a landscape engineer, and another, "Economic Tree Planting" by S. G. Northrup, Secretary of the State Board of Education, who had spent three months in Europe visiting forestry schools and plantations under a commission from Governor Hubbard.

In 1880, Reverend William Clift of Windham County lectured on "Forest Culture" to the State Board of Agriculture. He, too, complained about the destruction of forests in Connecticut:

> The present condition of some of the countries around the Mediterranean Sea, once among the most productive in the world and sustaining an immense population, is a good illustration of the removal of forests.... The footprints of the destroyer are already visible in our waning forests, in the bleak and barren hillside pastures, in our shriveling trout streams, where the springs are mostly dry that once protected the fish in summer, in our water courses emptied of their treasure every summer, in our increasing droughts, stopping the mills upon the rivers, that once turned their wheels the year around and in the multiplying of reservoirs to catch the winter rains and hold them for summer use.... These are indicators that ought to awaken our citizens before it is too late.

The 1883 report contains a lecture by E. D. Goodwin "Modifying Effects of Forests on Climate." (Once again, see the later paper by Waggoner.) From the report for 1884, it seems the Legislature had instructed the State Board of Agriculture to study laws aimed at conserving the State's forests. A Committee on Forestry, consisting of T. S. Gold, W. H. Brewer, and B. G. Northrup, was appointed to prepare a report; at the meeting in 1885, Northrup spoke on "How Can We Promote an Interest in Forestry," suggesting laws to prevent forest fires and an amendment to the plantation law.

Reports for the next few years show continued interest in trees, but mainly in Arbor Day and planting of shade trees. Not until 1895 did forestry come into its own again with "A Century of American Lumbering," a lecture by Dr. J. T. Rothrock from Pennsylvania.

FORESTRY IN THE FIRST YEARS OF THE STATION

The Connecticut Forestry Association was formed in 1895. Jenkins was a member, and, later, an officer. Otherwise, during the 'nineties, the State and the Station drifted along with only Sturgis and Britton showing a modicum of interest. Then, in 1900, Jenkins purchased land to be used for forestry research in Mundy Hollow and Rainbow in central Connecticut with funds from the newly acquired Lockwood Trust. This became the country's first experimental forest.

On July 1, 1901, he hired Walter Mulford of Cornell to be the first Experiment Station forester in America; the same year the Legislature first authorized the purchase of "barren land" for a state forest and ordered the Station Forester made "State Forester."

Mulford left in 1904. He later became Dean of Forestry at the University of Michigan, and still later Dean of Forestry at the University of California at Berkeley, where the forestry building is called Mulford Hall.

ROLE OF FORESTRY IN THE STATION

The *art* of forestry has played a unique and interesting role in the life of the Experiment Station. The *science* of forestry has been conducted largely in other departments: genetics, entomology, plant pathology, soils, and biochemistry. Only recently has the Forestry Department begun to carry a share of the basic research for which the Station is well known. Until then, with few exceptions, the foresters considered such practical aspects of forestry as how to deal with low-grade second-growth trees. Should one make them into charcoal? Study wood preservation so they can be used for highway posts? Protect pines by killing *Ribes*? Glue strips together to make laminated wood?

DEVASTATING PESTS

Connecticut forests have surely been invaded by more than their share of pests. In the middle of the last century, the elm leaf beetle chewed up the elms in the City of Elms, and they still chew them if the trees are not sprayed. In the early part of this century, the forests began to be invaded by a series of destructive pests. The first, and undoubtedly the most destructive, was the chestnut blight, which cleaned out the chestnuts along the entire Appalachian chain from Maine to Georgia.

CHESTNUT BLIGHT

The chestnut blight disease makes a sad story for American scientists. They worked their heads off on it, but to no avail. The fungus marched right through the gorgeous chestnut forests of the eastern seaboard. Clinton, who hated to admit defeat, did his share of work on it. In fact, he maintained his optimism until the day he died. Clinton was no dummy. Apparently he based his optimism on a prescient paper by Stoddard and Moss in Bulletin No. 178, published in 1913. They wrote: "Instances have been noted where trees were overcoming the disease and blight cankers that had attained a diameter of 18 inches were healing over, this process having begun in 1911." They were probably seeing hypovirulence, a phenomenon discovered recently in Italy and France, and introduced into this country by Dr. Peter Day.

When the disease first appeared and began to kill chestnuts, the citizens, as usual, demanded that the "Government do something" about it. By 1912 the chestnut blight had become very serious in Pennsylvania. The Governor called a conference of chestnut blight aficionados in Harrisburg. George H. Hepting discusses the conference in his elegant history of the disease (*Journal of Forestry History* 18:6-67, 1974). Hepting says that, during the conference, F. C. Stewart, a former student of Thaxter's at Harvard, argued in the face of almost fanatical opposition that: "It is better to attempt nothing than to waste a large amount of public money on a method of control [eradication] for which there is every reason to believe cannot succeed.... It can safely be predicted that nothing man can do will materially affect its course." Stewart was seconded by M. T. Cook of New Jersey, Westley Webb of Delaware, W. A. Murrill of New York City, and G. P. Clinton of Connecticut. Despite Stewart and company, the State of Pennsylvania spent $500,000 without "affecting its course." Such is politics.

In 1971, Dr. Peter Day, traveling in Europe, discovered the work of Grente in France on hypovirulence, and the Station has studied it ever since. Clinton would be happy, for it seems to be a possible means of biological control. As of 1990, however, Anagnostakis and Ellison have not been able to find a means of transmitting the agent that confers hypovirulence except by direct inoculation. That such an agent exists, however, is evidence that Stoddard and Moss did see hypovirulence in 1913. They found no evidence that cured cankers occurred in clusters, although they did observe cankers healing over.

This no doubt provided the basis for Clinton's continued optimism that the blight would fade out as some other pests had. If hypovirulence did not spread much in 1913, it is not surprising that it does not spread much now. That it is still here suggests occasional movement occurs. Herein lies a real challenge to researchers. Can they discover a way to make it spread?

FORESTS HAVE OTHER PROBLEMS

White pine blister rust hit the State about the same time as the chestnut blight. Filley and Riley of the USDA spent a lot of effort trying to control this disease by eradicating the *Ribes* bushes that act as alternate host. This effort presumably had some success because blister rust currently exists in only a few isolated pockets in the state, presenting no serious threat to white pines today.

The gypsy moth is perhaps the most spectacular of the invaders, because it impacts on city people by chewing up the foliage on their yard trees. It seldom kills healthy trees, however; it just defoliates them. Oaks are more likely to die than other trees. This pest is discussed in detail in the chapter on entomology.

The willow scab fungus invaded Connecticut in 1927, but it has not been as destructive as the pests detailed above. The dreaded Dutch elm disease has felled at least ninety-five percent of the elms in Elm City and other cities in the State. The federal government spent fabulous sums trying to eradicate it and failed. In 1939 the designers of the New York World's Fair introduced the red pine scale. It spread across Connecticut, killing red pines as it went.

Historical Markers along the Organizational Road

1901. Walter Mulford appointed first Station and first State Forester.

1904. Alfred Akerman appointed Station Forester. He resigned after two months, and Austin F. Hawes was appointed to the post.

1905. Hawes become *ex officio*, the first State Forest Fire Warden.

1909. Hawes resigned. W. O. Filley served as acting Forester for six months. Samuel N. Spring (who later became Dean at Syracuse University) became Forester. W. O. Filley was appointed Assistant Forester during Spring's term.

1912. W. O. Filley appointed Station Forester.

1919. Tree Protection Examining Board established to protect the public against ignorant and indiscriminate pesticide application (forty three years before Rachel Carson and *Silent Spring*). The Board consisted of 3 Station scientists.

1924. At Stamford, first meeting of organization that became National Shade Tree Conference. Britton elected President; Filley elected secretary.

1927. Hicock, Lunt, Morgan, Bull, and Lutz established bench mark transects in a wide range of forests to see if tree species were associated with soil type. Although this could not be proved, the plots have subsequently become the largest continuously monitored series of permanent plots in the Eastern hardwood forest.

1934. Filley made State USDA Agent in project to eradicate Dutch elm disease.

1940. Connecticut Charcoal Kiln developed to provide wartime fuel and income from second-growth forest.

1945. Filley retired. Hicock appointed Forester.

1952. An entire issue of *Frontiers of Plant Science* devoted to The Suburban Forest.

1955. United Nations sent Richard Olson to Iran to introduce the Connecticut charcoal kiln.

1959. Benchmark transects established in a wide range of Connecticut forests.

1962. Filley memorial plaque unveiled at Sleeping Giant State Park. Lockwood Conference on Forest Ecology; proceedings published as book.

1963. Station scientists serve on Governor's Committee on Pesticides that proposes Pesticide Control Board.

1964 to 1969. Waggoner's experiments in forests showed that modifying stomatal opening can change the hydrologic cycle and conserve soil water.

1967. Native ornamental shrub collection at Lockwood Farm completed and presented to the public. Examining the 1927 transects, Stephens found extensive changes in tree growth and distribution after forty years.

1968. Waggoner made a computer simulation of the microclimate in a forest and showed the impact of leaf area and stomata upon temperature and evaporation in the canopy.

1969. Plant pathologists discovered that leaves scrub pollutants from the air, and that the contribution of forests to atmospheric cleansing can be calculated. Board of Control moved Forestry into new Department of Soil and Climatology.

1974. Stephens related tree mortality to insect defoliation.

1980. Forestry reestablished in a new Department of Forestry and Horticulture. George Stephens made Chairman.

The Professional Staff of Foresters

W. Mulford	1901-1904	H. J. Lutz	1927-1928
A. Ackerman	1904-1904	H. Bull	1929-1931
A. F. Hawes	1904-1909	A. R. Olson	1938-1964
S. N. Spring	1905-1912	J. S. Olson	1951-1958
A. E. Moss	1912-1919	S. Collins	1957-1962
W. O. Filley	1912-1945	G. Stevens	1957-date
H. W. Hicock	1919-1955	K. Loach	1964-1966

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Soil, Water, and Climatology

More complex than the others, this chapter will open with a report on soil before going into water, climatology, and ecology.

SOILS

Since soil is the basis of agriculture both figuratively and literally, it occupied a front and center position in the thinking of the founders of the Experiment Station, Norton, Johnson, and Jenkins. In fact, Johnson sold the Station to the legislature by showing that his chemistry could detect fraud in fertilizers. For that reason it is astonishing that a soils department was not established until 1923, when the Station was nearly a half century old.

This first part of the chapter will deal with the Connecticut thinking on soils from the days of Liebig in 1840, to 1975 when the Station completed its first century.

THE MORGAN SOIL TEST

Because many consider the Morgan soil test one of the major contributions of the Station to society, it will be discussed first.
Ever since Liebig published on plant nutrition in 1840, controversy had raged among the soils fraternity over whether chemistry could be used to measure soil fertility. After nearly a century, the controversy reached a climax in 1933 with the first publication of M. F. Morgan's soil test in Station Bulletin No. 372.[12] Yes! Chemistry could be used to measure soil fertility.

Morgan continuously improved the methodology, publishing more bulletins along the road; No. 392 in 1937, and No. 541 (posthumously) in 1950. An excerpt from the 1963 *News Letter of the Potash Institute Inc.* attests to Morgan's contribution:

> The Morgan soil testing system, Bulletin 541 published by The Connecticut Agricultural Experiment Station, is dedicated to the late Dr. M. Francis Morgan.... It is a fitting memorial to Dr. Morgan, one of the earliest pioneers in this field. His pioneering spirit and courage helped enormously in pushing back the frontiers of science in this field of soils research.... It offers a valuable contribution to the more intelligent management of America's greatest resource – the soil.

This is indeed a fitting tribute to Lieutenant Colonel M. F. Morgan PhD, who nineteen years earlier, had been killed from ambush on Leyte in the Phillipines. Thus perished the inventor of the Morgan Soil Test. The 1955 Station Report noted that the bulletin describing the Morgan system was requested by more people than any other.

SOILS BEFORE THE STATION WAS ESTABLISHED

Let us now go back to Liebig's time and follow work on soil testing prior to the establishment of the Station. In 1844, shortly after Liebig's work, J. F. W. Johnston struggled unsuccessfully with the problem in Edinburgh, Scotland. (For more on Johnston see Chapter 2, "The Gestation Period.") Babeny, in 1845, showed that only part of the plant nutrients in the soil is available to the plant. He was right, but how to measure it? Ville was pessimistic in his 1862 paper, *Artificial Manures*. He wrote that "chemistry is powerless to throw light upon the agricultural qualities of the soil ... because it confounds ... the assimilable agents with the inert principles."

Morgan's secret was that *his* chemistry could so distinguish. Had Morgan "known the right people," he might have been awarded a Nobel Prize for his bright idea, but Morgan was too modest. Well, let us get on with history. J. P. Norton, as mentioned in Chapter 2, worked at Yale under the Sillimans in 1847. In 1850, after he went to Edinburgh and worked with J. F. W. Johnston, he published *Elements of Scientific Agriculture*, a text in which he came close to, yet remained so far from, Morgan's secret. Instead of using strong acid as an extractant, as did his predecessors, he used dilute hydrochloric acid in boiling water; but that did not work either.

SOILS AFTER THE STATION WAS ESTABLISHED

S. W. Johnson, the first Director, was long interested in soils. This was tied, of course, to his use of chemistry to detect fraud in the fertilizer market place. In the 'fifties and 'sixties of the last century he delivered several lectures before the State Board of Agriculture. One, "On the Physical Properties of Soil as Affecting Fertility," was surely a forerunner of his appointing Osborne in 1886 to work on the physical properties of soil. Another lecture was entitled "The Soil as Related to Agricultural Production." In 1873, he lectured on "Guiding Ideas in the Use of Fertilizer." Like other chemists of the time, he was interested in measuring fertility by chemical means, but he saw the limitations. He was as frustrated as other chemists when he wrote: "It became evident that simple analysis could not give us the definite and decisive information that had been expected of it." He added that, "did he own a farm, he would be likely to test its soils by chemistry in respect to several points; but in my farming I should depend more upon what the crops say than upon what my analyses might reveal." He simply could not quite change from the thinking of a chemist to the "thinking" of a plant. Johnson is saying

that plant roots in soil are better chemists than he. Morgan's concern was with how this could be.

Johnson kept toiling with soils. In the 1877 Station report, the first under his tutelage, Johnson wrote "Reasons for Tillage," a paper that Morgan described as a classic and that Baver quoted in his 1940 book. In that paper, too, C. R. Frink discovered a passage where Johnson reported having asked his chemist, Armsby, to prepare a summary of what was known at the time regarding the relation of soil to water. After reading Armsby's review, Johnson said, "The matter has been the subject of much thought and experimental work that in some directions it appears to be fairly understood, but in others it is yet obscure."

As soon as he had money to spare, Johnson appointed the brilliant young man, T. B. Osborne, to the staff to work on the physical properties of soils. In the report for 1886, Osborne published his first paper, "Methods of Mechanical Soil Analysis," describing a beaker-elutriation method that was adopted by the USDA and continued to be used for several decades. For reasons of his own, Osborne dropped work on soils and turned to the field of protein chemistry.

Milton Whitney worked on soils at the Station for a few months in 1882. He left for the Bureau of Soils in the USDA and returned to Connecticut in 1899 to set up the first soil survey in the country.

Vice-Director Jenkins did his share to keep soil work alive at the Station. He was particularly active in fertilizer research, as shown in the reports for 1889 (p. 202), 1891 (p. 139), 1892 (p. 122), 1893 (p. 288), 1894 (p. 245), and 1896 (p. 235). The 1894 report mentions a greenhouse where Jenkins conducted pot experiments for several years.

E. M. East, who came to the Station in 1905 and became famous for his work on hybrid corn, was concerned with soils, too. "In connection with Mr. East's breeding work, a study is being made of the improvement of a common type of sandy loam by means of a rotation including the use of leguminous crops and a moderate use of fertilizers." (Report for 1906, p. xvi.)

After that, soils disappear from the reports for ten years, but the report for 1916, p. 58, remarks that more than sixty samples of soil were tested for acidity. Further, ten tobacco soils were analyzed, four by the hydrochloric acid extraction, and six by water percolation. They kept fighting the bogey.

Four years later Jenkins reported (Bulletin No. 350) on an experiment with top dressing of fertilizer on a run-out meadow on the Lockwood farm at Mt. Carmel.

MORGAN ARRIVES

On July 20, 1923, M. F. Morgan arrived at the Station with a new master's degree from Ohio State University. (A few years later, he received his doctorate there.) Working alone, he promptly began a soil survey in the Town of Lebanon. He had an office on the upper floor of the Station Library, later moving to the lower floor of the Thaxter Laboratory. He, too, worked on fertilizer requirements in a small lean-to greenhouse attached to the south side of the Thaxter Laboratory. In 1924, Morgan was the first researcher in America to use aerial photography in soil survey.

THE FIRST VERSION OF THE MORGAN SOIL TEST

What motivated Morgan to enter the field of soil testing? It hardly seems a likely choice for a soil surveyor. Reports show that, in 1933, he published a microchemical soil test "to analyze soil simply and quickly as to phosphorus availability, nitrate nitrogen, active aluminum, and replaceable calcium." The same year Morgan published the first complete version of his method in Bulletin No. 372, *The Universal Soil Testing System*. He put his finger on the essence of the system by stating: "The distinguishing characteristic of this scheme of testing is the employment of a highly buffered mixture of acetic acid and sodium acetate for the extraction of the soil. All of the significant tests are conducted on portions of this extract; hence great speed and economy of operation are provided." The report for that year says that the Station had tested more than one thousand samples for citizens.

Morgan's predecessors for nearly a century had extracted their soils with strong acids or water and analyzed the product. Their efforts typified a principle in the sociology of science. They looked at soil with the eyes of a chemist, not with the "eyes" of a plant. They never asked what the plant used to "extract" the minerals it needed from the soil. Morgan did. Being young and venturesome, he flew in the face of dogma. Instead of using the chemists' hydrochloric acid, he imitated the excretions of plant roots.

Morgan's method gained support rapidly. In the report of the very next year (1934), he wrote that "our system is being used by numerous experiment stations, extension services, and commercial agencies." In 1935, his laboratory tested 4500 samples.

THE SECOND VERSION OF THE MORGAN SOIL TEST

By 1936 his Bulletin No. 372 was out of print, and Morgan published Bulletin No. 392. This, too, was soon out of print. The 1949 report of the Station states: "Soil testing has definitely passed out of the innovative stage to a rightful place as a useful tool for achieving better land management. The Morgan soil testing methods are being used almost universally."

Presumably this is what stimulated his colleagues – Lunt, Swanson, and Jacobson – to publish the next year a revised and updated version of the method as Bulletin No. 541. They dedicated it in Morgan's memory. Two years later this 1950 bulletin was translated into French, and the 1957 Station report records that several copies of the Morgan bulletin were taken from reserve to fill a request from Taiwan.

MORGAN'S WAR SERVICE

Morgan served in the First World War, attaining the rank of Captain. He was awarded the Distinguished Service Cross and the *Croix de Guerre* for bravery. He maintained his military interest in peacetime, attaining the rank of Lieutenant Colonel. When World War II started, he returned to active service. In February 1944, his jeep was ambushed on Leyte. Perhaps in anticipation of this possibility, he wrote in 1941 a long history of soil work in Connecticut prior to the establishment of the Station. A portion of his first paragraph and all of the last paragraph bear repeating. In the first paragraph he stated:

> In 1840, Liebig, with the rapier of his fine ridicule, had slain the old 'Humus Theory' of plant nutrition, expounding the doctrine that plants find their nutrient material only in inorganic substances and that the carbon of plants must be obtained only from the air.

His last paragraph says:

> I shall not attempt to discuss the development of various phases of soil research to which members of our staff have devoted their attention during the nearly eighteen years of gradual growth in activity since our establishment as a separate department – such as detailed soil surveys,... land classification, soil fertility studies on a wide range of soil in greenhouse tests, the methods for rapid chemical soil tests, field and forest lysimeter investigations, field fertility experiments with vegetable crops, forest soil type studies, forest nursery experiments, hydroponics, and so on. We have attempted to be true to the best traditions of service to agriculture that have characterized the Station throughout its history. Yet we are humbled by the knowledge of soils of three-quarters of a century ago, as reflected by the teachings of our first Director, and are inspired to strive more zealously to build our structure of expanding soils knowledge more worthy of the foundation prepared from the finely sifted fact that has been passed on to us by such men as Norton, Johnson, and Jenkins.

WATER

At this point we turn from soil to water.

By 1948, Lake Zoar had become so full of algae that people who dived in for a swim came up colored green. They thought the Station should "do something about it." At the time, the Station was in one of the periodic job freezes, but upon request, Governor Bowles unfroze one vacancy and Dr. Dimond appointed a Yale graduate student, Richard Benoit, to examine the problem. He very soon showed that the algae were thriving on phosphorus discharged from the factories in Danbury that were making men's hats. As the popularity of men's hats faded, so did phosphorus in the lake, and so did the algae.

In 1965 Governor Dempsey appointed Waggoner to his "clean water task force."

Frink became interested in the eutrophication of lakes in 1966. (Eutrophic is a Greek word meaning "well nourished.") Frink's first study was of Bantam Lake in northwest Connecticut, where he showed that the phosphorus was recycled from sediments on the bottom. In 1967, he wrote a landmark paper entitled "Nutrient Budget, a Rational Analysis of Eutrophication in a Connecticut Lake," and in 1968, cooperated with the Water Resources Commission to study nutrients in the Housatonic River.

In 1970 Hill published a bulletin on a survey of coastal wetlands.

In 1973, using the Trophic State Index developed in Florida, Frink ranked five Connecticut lakes in the proper order of eutrophication. The N. E. Branch of the American Society of Agronomy awarded him their 1974 Research Award "for Outstanding Achievement in the chemistry and meteorology of acid soils and the cycling of nutrients in soil, water, and sediments." His nutrient budget for the State of Connecticut has helped to establish priorities in providing clean water.

CLIMATOLOGY

Climatology is discussed here, because it has been entangled with soil and water in the history of the Station.

When P. E. Waggoner joined the staff of Plant Pathology and Botany in 1951, after having served as a meteorologist in the Air Force during the war, he was more interested in climatology than in plant pathology. For that reason, in due course, a Department of Climatology was established in 1955. Swanson left the soils department, and his staff was transferred in 1956 to make a new department of Soils and Climatology.

In 1962, using Lockwood funds, Waggoner organized a National Conference on Forest Ecology, where eminent biologists delineated the problems peculiar to forest and suburbs and suggested ways by which ecology could help solve them. The proceedings were published.

Waggoner's 1963 bulletin, "Plants, Shade, and Shelter," showed how trees, thickets, parking lots and beaches affect human comfort.

In 1965, Waggoner was a guest of President and Mrs. Lyndon B. Johnson at a White House Conference on Natural Beauty, and in 1966, he was given an award for Outstanding Achievement in Climatology.

In experiments in forests from 1962 to 1969, Waggoner was able to change the hydrologic cycle and conserve soil water.

The study of water was moved in 1969 from the Department of Climatology into a new Department of Soil and Water, with Frink as chief, and Climatology was enlarged to include Ecology under Waggoner.

Historical Markers along the Organizational Road

1850. Norton's book *Elements of Scientific Agriculture Mid-Century.* Johnson's speeches published in the *Proceedings* of the State Board of Agriculture.

1882. Milton Whitney worked at the Station on soils.

1884. Thomas Burr Osborne began work at the Station on soils.

1889. Jenkins began extensive work on soils and fertilizers. Whitney returned to Connecticut as a USDA employee to initiate the first soil survey in America.

1923. Morgan established Department of Soils.

1942. Morgan went to war and died in 1944. Lunt made acting head.

1946. C. L. W. Swanson appointed head of the Department of Soils.

1955. Department of Climatology established.

1956. Swanson resigned. Soils moved into Climatology as new Department of Soils and Climatology; Waggoner made head.

***Circa* 1968** Waggoner made Vice-Director.

1969. New Department of Soil and Water; Frink made head. New Department of Ecology and Climatology; Waggoner made head.

1972. Frink made Vice-Director.

Researchers In Soils, Water, And Climatology
(Includes Researchers At The Valley Laboratory)

J. P. Norton	1847-1854	T. Tamura	1953-1956
E. H. Jenkins	1875-1923	A. Ritchie	1956-1957
H. P. Armsby	1877-1881	C. R. Frink	1956-Date
M. Whitney	1882-1882	D. E. Hill	1957-Date
T. B. Osborne	1886-1888	B. F. Sawhney	1958-Date
M. F. Morgan	1923-1944	C. Bingham	1958-1964
D. B. Downs	1924-1970	D. Moss	1959-1969
G. Scarseth	1925-1926	D. E. Peasley	1960-1966
H. G. M Jacobson	1926-1962	J. D. Hesketh	1961-1963
T. R. Swanback	1927-1952	S. L. Rawlins	1961-1964
H. A. Lunt	1928-1955	G. R. Stephens	1961-Date
O. E. Street	1939-1940	P. Rasmussen	1965-1967
S. B. LeCompte	1940	J. Boyer	1965-1966
E. J. Rubin	1941-1943	G. Heichel	1968-1976
C. L. W. Swanson	1946-1957	D. Aylor	1970-Date
G. A. Bourbeau	1948-1951	W. Norvell	1974-1978
O. Talvenheimo	1951-1952	L. Starr	1974-Date
H. DeRoo	1952-1976		

Visiting Scientists From Abroad

S. Duvevani	1960	Israel
D. Shimshi	1962-1963	Israel
J. P. Grime	1963-1964	England
K. Loach	1964-1966	England
Ben-Ami Bravdo	1966	Israel
P. J. G. Kuiper	1967-1970	Holland
Neil Turner	1967-1973	Australia
John Begg	1968-1969	Australia
Owen Denmead	1969-1970	Australia

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The Tobacco Laboratory

When the colonists arrived in Connecticut from England, they found the natives smoking pulverized dry tobacco leaves in a homemade pipe. The Indians smoked a "peace pipe" as a part of their ritual. An elegant early history of tobacco in Connecticut was published by Henry A. Dyer in the 1856 *Transactions of the Connecticut State Agricultural Society* (pp. 427-446). The following are excerpts from Dyer's paper.

> In the account of Cartier's voyage in 1535, we find it used in Canada. There groweth a certain kind of herbe, whereof in Sommer they make provision for all the yeere ... only men make use of it...they make powder of it, and then put it in one of the ends of a cornet or pipe, and laying a cole of fire upon it at the other ende, sucke so long, that they fill their bodies full of smoke, till it cometh out of their mouth and nostrils, as even out of the tonnel of a chimney.

The following is from a quaint old book, *An Account of Two Voyages to New England*, by John Josselyn, printed in London in 1638.

> Tobacco or Tobacca so called from Tobaco or Tobago, one of the Caribe Islands, about 50 English miles from Trinidad.... Great contest there is about the time when it was first brought to England, some will say Sir John Hawkins the first, other Francis Drake's mariners; others again say that one Mr. Lane employed by Sir Walter Rawleigh brought it first into England; all conclude that Sir Walter Rawleigh brought it first into use. It is observed that no one kind of forraign Commodity yieldeth greater advantage to the public than Tobacco, it is generally made the complement of our entertainment, and hath made more slaves than Mahomet.
>
> The Indians in New England use a small round leafed tobacco. It is odious to the English. The vertues of Tobacco are these, it helps digestion, the Gout, the Toothache, prevents infection by scents, it heats the cold, and cools them that sweat, feedeth the hungry, spent spirits restoreth, pungeth the stomach, killeth nits and lice, the juice of the green leaf, healeth green wounds, although poysoned, the syrup for many diseases, the smoak for the phthisick, cough of the lungs, distillations of Rheum, and of all diseases of a moist cause, good for all bodies cold and moist taken upon an empty stomach, taken upon a full stomach it precipitates digestion, immoderately taken it dryeth the body, enflameth ye bloud, hurtheth the brain, weakens the eyes and the sinews.
>
> As early as 1640, only three or four years after the first settlement of the towns along the river, the culture of tobacco had so far

progressed and the crop was deemed of such interest as to occasion for its protection the passage of the following act, *viz.*

June 15, 1640. *It is ordered that what prson or prsons within the jurisdiction shall, after September, 1641 drinke any othere Tobacco but such as is or shalbe planted wthin these libertyes shall forfeit for every pownd so spent five shillings except that they have license from the Courte.*

May 25th, 1647. *Forasmuch as it is obseured that many abuses are comitted by frequent taking Tobacco, it is ordered that noe prson vnder the age of 20 years, nor any other that hath not allready accustomed himself to the vse thereof take any Tobacco vntil he haue a Certificat vnder the hand of some who are approued for knowledge & skill in phisicke, that it is vsefull for him, and also that he hath receaued a lycense from the Court for the same.... It is Ordered that no man wthin this Collony after the publication hereof shall take any tobacco publicquely in the street, nor shall any take yt in the fyelds or woods vnless when they be in their trauill or joyrney at least 10 myles, or at the ordinary tyme of repast comonly called dynner, or if yt be not yet taken, yet not aboue once a day at most & then not in company with any other....*

Dyer writes about acts passed a century later:

To preserve the reputation of the tobacco from the Colony and to prevent frauds in its packing &c., an act as follows was passed in October 1753. The preamble states *'Whereas in many Townes in this Colony Tobacco is raised to be exported to Great Britain and to his Majestys Plantations. It is enacted that each town where tobacco is or shall be raised for exportation shall at their annual town meeting for electing Town officers choose two or more fit persons to be surveyors & packers of tobacco for the year ensuing who shall carefully survey & search the Tobacco by them to be packed & shall cull out and separate all such hands of Tobacco as are in whole or in part damnified by the infusion of any thing liquid, or by being kept too moist, or by frost, heat, or any other means whatever; and shall pack or press no Tobacco but what is by him judged to be sound, well ripened, sufficiently cured and in every way good and merchantable.'*

The tobacco that was cultivated in Connecticut previous to 1833, had a narrow leaf and was commonly called shoestring tobacco; about that time the broadleaf tobacco that is now so well known as the Connecticut seed leaf, was introduced from Maryland by Mr. B. P. Barber, of East Windsor. The broadleaf tobacco possesses certain peculiarities that render it exceedingly valuable for the purpose for which it is used. The leaves are broad, the veins are regular, and its weight is light in a large surface; it is less full of "salts," comparatively tasteless, and very pliable; hence, as wrappers for segars, it is unsurpassed.

The enemies of the tobacco plant are the cut-worm which attacks the young plant very soon after it is set into the field, and the tobacco worm. The only remedy for loss from the first of these depredators is having a plentiful stock of new plants and using constant vigilance in resetting as fast as they are destroyed. The tobacco worm is the Larva of the Sphynx Carolina.... It must be watched with unceasing care and diligently destroyed or its ravages will blast the hopes of the planter.

The cultivator of this crop may have managed all the details of its culture and may have secured a splendid growth of tobacco ... yet his hopes may be blasted and his prospective success result in the most disastrous failure if the after processes of its cure are not managed with that care and judgement that only experience and thorough knowledge of what is required can give. Therefore any man who is not thoroughly conversant with the curing of the crop would do well to employ someone who has the skill and can be entrusted to manage it for him. *[This anticipates the research on curing that Jenkins initiated around the turn of the century.]*

The crop will average, say 1,500 pounds to the acre; meadow and heavy land producing 2,000 pounds; but that raised on sandy land, is of a thinner texture and burns more freely.

For manures, horse is the best, next is barn-yard. *[Johnson later explained this, showing that chlorine inhibits burn. Cow manure contains considerable chlorine.]* Of the modern fertilizers, calling Peruvian guano the best; I do not think they will pay, except perhaps, in a small way in hill, as stimulants.... We all know that it is a very exhausting crop, using three-fourths or more of the manure the first season. *[During the century before automobiles, Connecticut tobacco farmers imported by sea innumerable barge loads of horse manure from New York City's street sweepings.]*

Previous to the year 1801, the whole amount of tobacco raised in any one year in Connecticut did not exceed ten tons, this was the average crop....

In 1801-2 Mr. Noah Rockwell, with Mr. Bingham, began to make plug and twist tobacco in East Windsor. These gentlemen procured a man from Virginia named Prout to assist them in the operations of their business. To his wife belongs the honor of instituting the business which has now become one of so much importance, the manufacture of segars....

The manufacture of these segars went on in families until 1810, when Mr. Roswell Viets, conceived and executed the notion of establishing a regular manufacturing establishment for segars in East Windsor.... The average of wages earned by the men was $6 per week, by the women $4. *[The ratio doesn't seem to have changed much in the two hundred years since.]*

ISRAEL PUTNAM INTRODUCES CIGARS

Jenkins, in his article "History of Connecticut Agriculture" says:

> Col. Israel Putnam, of Wolf Den fame, is credited with the introduction of cigars into Connecticut. It is said that he went as Lieut. Col. of the first Connecticut Regiment in the expedition against Havana in 1762. While there, he saw the natives smoking a big roughly rolled cigar. He tried them and liked them so much that he brought home "as much as three donkeys could pack."

As noted above, the manufacture of "seegars" in Connecticut was begun by Mrs. Prout forty years later in 1801-2.

The next references to tobacco are found in Professor Brewer's lecture to the famous Yale Agricultural Course on February 15, 1860. Some excerpts from that address:

> Nicotine, the deadly principle to which all the ill effects of tobacco are due, is, as every one knows, a deadly poison.... The ash is of all the most important to the farmer, for this is made up from his available plant food – in other words from his farm capital. The oils, resins, and acids come from the air and cost us nothing. Take a given quantity of tobacco and burn it to ashes, and we find that the proportion is enormous. The roots give two to fourteen per cent of ash, the stems dried sixteen, and the leaves seventeen to twenty two per cent. As the leaves are the great bulk of the crop, the robbery of the soil is correspondingly great. One thousand pounds of tobacco takes an average of 200 pounds of ash....
>
> Now a crop of wheat of thirty bushels to the acre takes but thirty-six pounds of ash from our farm. In other words, it would require eleven crops of wheat to do as much damage as a single crop of tobacco.... A study of the census will show us, that in any tobacco district, the production starting at nothing mounts rapidly to a maximum, turns the corner, and never regains its higher figures....

Brewer considered the advantages and disadvantages of tobacco culture:

> The sole advantage is that an individual may grow rich from raising it. On the other hand, a nation never will; for one man's gain is obtained at the cost of his son and son's son; in getting his fortune he has taken from his children the means of future gain, like the owner of the goose that lays the golden egg. *[This accounts for the common observation of Virginia genealogists that the tobacco farmers there moved west up the rivers as their land "wore out."]*

The next historical reference to tobacco in Connecticut is found in a report by S. W. Johnson, in his role as chemist to the State Board of Agriculture, in its *Proceedings* for 1872 (p. 384). He does not cite the paper his student, Brewer, had given during the

Agricultural Lecture Series that Johnson had organized. Perhaps he was trying to establish his own priority because he said that the only analysis of tobacco he could find was in Europe.

As Brewer had twenty years earlier, Johnson speaks of the enormous demand tobacco makes on soil fertility and states that potassium is the most important ingredient for growth and burning. He adds another bright idea: "Chlorine is detrimental to burning." [This explains Dyer's remark that horse manure is best; since cows require large amounts of salt, their manure is full of chlorine.]

THE TOBACCO EXPERIMENT COMPANY

The Station neglected tobacco for the first seventeen years of its life, but the farmers formed The Connecticut Tobacco Experiment Company in 1892 and asked the Station to cooperate with them. Station reports from 1893 to 1898 contain accounts of this group's research. Their first job was to build an experimental curing barn at Poquonock. In his fifty-year history, Jenkins tells a sad tale about this barn (p. 49):

> In 1898 they tried the use of heat in this barn. I stayed by the barn all day and often at night reading my hydrometers and thermometers and tending fires and ventilators. At last the job was done and all that was needed was to let the fire go down and wait for the first damp weather to take down the cured leaf. My tiresome job was done and I could go for a vacation in the White Mountains. I took the trolley at Poquonock and at a place on the line where the experiment field was in sight, I gave it a last look – and saw the barn in flames and my year's work on tobacco gone. I kept going and did not stop until I got to Forest Hills – and my wife.
>
> In 1898 with the cooperation of M. L. Floyd of the U. S. Department of Agriculture, we tried the experiment of fermenting the tobacco in a bulk instead of in cases.... Dealers who saw it and felt the heat within the bulk, sometimes 100° – 120° declared that we had ruined it but being offered a dollar for every damaged hand they found, they did not make a cent. The method, perfected by experience, is now used in fermenting all shade grown and much Havana seed tobacco.

In 1898 Sturgis spent considerable time working on "pole rot" or "pole sweat," a disease of tobacco in the curing barn. To get more ventilation, he designed a barn with vertical ventilators, one for each row of tobacco in the barn. This type of tobacco barn is still the standard in Connecticut. Sturgis also helped M. F. Floyd introduce the tobacco shade tent to Connecticut. These shade tents, used to this day, are impressive to first time visitors to the state.

WILDFIRE APPEARS: THE TOBACCO LABORATORY IS ESTABLISHED

Except for a little breeding work by East and Jones, tobacco received no more Station attention until the wildfire disease appeared in 1919. Wildfire, a bacterial disease, invaded Connecticut from the South, greatly agitating tobacco farmers and spurring the organization of a second experiment station, the Connecticut Valley Tobacco Improvement Association, in 1921.

In a fashion reminiscent of the way the Connecticut Tobacco Experiment Company was formed twenty-nine years earlier, the Association persuaded the state legislature to appropriate $10,000 for research and improvement of tobacco. The Legislature approved the $10,000, but did not approve its use for the purchase of land. Three farmers purchased thirteen and one-half acres of tobacco land with three tobacco barns at Windsor. Jenkins subsequently reimbursed them with Lockwood funds.

The Association formed a loose affiliation with the Station in New Haven. They hired Dr. George H. Chapman from Massachusetts State College as the first director, but he was also put on the staff at New Haven. A contract was drawn, specifying that research be jointly decided upon by the Director of the Connecticut Valley Tobacco Improvement Association, the Director of the Station at New Haven, and Mr. Joseph Alsop, who represented both. When, gradually, growers pulled out of the enterprise, the Experiment Station called it the Tobacco Substation, a new department.

TOBACCO PESTS ENCOUNTERED

Over the years tobacco seems to have been a species susceptible to all manner of pests. As early as 1856, Dyer had mentioned the occurrence of the huge tobacco worm that ate the foliage, and the cut worm that ate off the stems of transplanted seedlings. Forty years later Sturgis wrote of the "calico" disease of tobacco, now called tobacco mosaic. As was mentioned in the chapter "Plant Pathology," his 1898 paper was the first in America to treat a plant virus disease.

When the dreaded wildfire disease invaded Connecticut in 1919, Clinton and McCormick researched it extensively; by the early 'twenties, they showed that it could be controlled with copper fungicides applied in the seedbed. Incidents of the disease fluctuated considerably, but slowly faded out – so much so that Anderson's report for 1941 was labeled "Exit Wildfire," and contains the following remarks:

> This is the first season in 20 years that the writer has failed to see or hear a report of a single case of wildfire in the Connecticut valley. After its spectacular outbreak and destructive spread in the early 'twenties, wildfire began to be less prevalent each year. This gradual tapering off process continued until during the late 'thirties it was unusual to find more than a dozen cases any year, but each year there were always a few. Now it seems to have dropped out completely. Such behavior for any plant disease in quite unusual in plant pathology.

Perhaps natural selection had uncovered a resistant gene. Four years later, Anderson looked again at wildfire and wrote: "In Glastonbury it reached epidemic proportions and was found in a more or less large percentage of the Broadleaf fields, but in most parts of the Valley, it occurred only in an occasional field and was usually not of serious consequence...."

1945 was an unusually wet year. Now we are confronted with a puzzle: was 1945 just another 1938, followed by still another disappearing act – or was it the beginning of another series of epidemic years? Wildfire occurred occasionally until 1965, but has not been reported since then. Whatever the cause of the decline of wildfire in the Valley, it is reminiscent of the decline of peach yellows in the orchard or of the browntail moth in the forest.

In 1937, a new disease, blue mold, blew in from the South. It was most serious in the seed bed. Anderson controlled it by fumigating the seedlings with benzene vapor. In 1956, Waggoner began research on the physics and meteorology of the dispersal of fungus spores in the air, using the blue mold fungus.

In 1951, a man-made disease appeared on tobacco of the Valley. Its cause unknown, it was labelled "weather fleck." Eventually, others showed that fleck results from ozone thrown into the air during inversions by the exhausts from the multitude of automobiles and trucks in Hartford and vicinity. In 1961, Seward Sand of the genetics department discovered genes for resistance. Without those resistant genes, we would not be able to grow tobacco in the Valley today.

Other diseases, of more or less minor importance, that have affected Connecticut tobacco are Fusarium wilt, angular leaf spot, black root rot (related to high pH in the soil), brown root rot (due to toxins from the decaying roots of a timothy cover crop), and root lesion nematodes (discovered by Anderson). Black shank was discovered by Taylor in 1972.

Historical Markers Along The Organizational Road

1892. The Connecticut Tobacco Experiment Company was established in Poquonock.

1921. The Tobacco Station was opened. G. H. Chapman, first Head.

1924. The Tobacco Station was renamed the Tobacco Substation. P. J. Anderson made second Head.

1953. P. J. Anderson retired. Gordon Taylor made head with title of Assistant to the Director.

1955. So-called "homogenized tobacco" hit the State. Pulverized leaf fragments were formed into sheets with plastic and used as binder, the second layer in a cigar. This severely wounded the outdoor tobacco business and many farmers turned to the nursery business.

1965. Tobacco Laboratory renamed "Valley Laboratory."

The Tobacco Experimenters

At Windsor

G. H. Chapman	1921-1927	S. B. LeCompte	1940-1944
C. M. Slagg	1921-1924	A. B. Pack	1947-1955
N. T. Nelson	1924-1927	E. Peterson	1949-1953
P. J. Anderson	1925-1953	G. Taylor	1953-1987
T. R. Swanback	1927-1952	H. C. DeRoo	1952-1979
O. E. Street	1926-1939	J. F. Ahrens	1951-Date
A. W. Morrill (USDA)	1936-1942	D. E. Hill	1957-1965

At New Haven

S. W. Johnson	1877-1900	D. E. Greenwood	1943-1948
E. H. Jenkins	1891-1902	S. Rich	1947-1984
W. C. Sturgis	1891-1902	B. F. Lounsbury	1951-1953
G. P. Clinton	1902-1936	M. Zucker	1954-1971
E. M. East	1905-1909	S. A. Sand	1954-1964
D. F. Jones	1915-1961	P. Miller	1954-1979
Florence McCormick	1917-1941	D. E. Hill	1957-Date
H. Hicock	1919-1959	H. Tomlinson	1965-1974

13

The Tale of Two Stations

Connecticut has two agricultural experiment stations. The whys and wherefores of this curious situation will constitute the content of this, the last chapter in the book.

As we have seen in the first twelve chapters, the first station in Connecticut and the first in the nation, was The Connecticut Agricultural Experiment Station established in 1875. The second in Connecticut was the Storrs Agricultural Experiment Station established 12 years later in 1887 by the Hatch Act. No one has published a history of The Storrs Agricultural Experiment Station but, writing on the occasion of the University of Connecticut's fiftieth anniversary, Walter Stemmons included a history of the Storrs Station.[13] I shall make much use of his book in this chapter.

THE STORRS AGRICULTURAL SCHOOL

During the last century much effort was expended in America to establish schools to raise the intellectual level of farm boys. One of these farm schools was the Cream Hill School, established in 1845 by Dr. Theodore S. Gold in West Cornwall, Connecticut. It survived for twenty-four years. G. J. Brush, later Director of the Sheffield Scientific School of Yale, was a student. The Gold family was involved for several generations in the farm school development.

THE ROLE OF YALE UNIVERSITY

Yale played a large role in developing agricultural education in the nineteenth century. Stemmons wrote: "To Yale must go the lion's share of the credit for the early efforts in the State on behalf of agriculture. It was no accident that Yale was made the beneficiary of the Land Grant Act in 1863." Prior to the passage of that act, it is doubtful if any American institution had made a contribution to agricultural science comparable to that of Yale. As we have seen earlier, Yale organized a three-week school on scientific agriculture in 1857; Yale also educated S. W. Johnson, who fathered the experiment station idea in America. Several of Johnson's students became directors of new stations that were formed, and one of them, Wilbur Atwater, was made first director of the Storrs station.

The beginning of the end for Yale in agriculture began with the action of two farmers, Charles and Augustus Storrs, who left their farm in the Mansfield hills in eastern Connecticut and went down to Brooklyn, New York to make their fortunes in the textile business. In order to help with agricultural education in Connecticut, they made a proposition to the 1880 meeting of the Connecticut Board of Agriculture, offering the State one hundred seventy acres of land

and $5,000 in cash to establish a school of agriculture. The Board appointed a committee composed of Professor W. H. Brewer of Yale (the Land Grant School), J. B. Olcott, and Dr. George A. Burns to take the idea to the General Assembly.

Brewer wrote, "He went before the Committee of the General Assembly and advocated the acceptance of the idea." Later, he may have regretted this act that, one day, would take the Land Grant Charter away from Yale. The General Assembly accepted the Storrs' proposal and established the Storrs Agricultural School. Its charter specified, among other things, that $5,000 be appropriated annually, and that the Director of The Connecticut Agricultural Experiment Station be an *ex officio* member of the Board of Trustees. The new Board of Trustees sent three of its members, T. S. Gold (of Cream Hill Farm), S. W. Johnson (of the New Haven Station), and J. B. Olcott to visit the agricultural school at Guelph, Ontario "in order to prepare themselves." The Station sent a staff member, H. P. Armsby, to Storrs as Vice-Principal and professor of chemistry. Atwater made a speech at the formal opening of the school. Thus, it is fairly clear that the Connecticut Station actively supported the idea of the new farm school.

There is even more evidence for this. Stemmons says that Professor Brewer, a member of the Board of Control of the New Haven Station, "came valiantly to the defense" of the Storrs school and its location when some citizens said at the 1884 meeting of the State Board of Agriculture that the soil on the Storrs farm was too poor, and that the school should be moved. No one, however, came from Storrs to support Yale when, ten years later, the Grange opened its proposal in the General Assembly to move the Land Grant Charter from Yale to Storrs.

The Connecticut State Grange had been reorganized on June 24, 1885 in Hartford. The Worthy Master J. Hale (of peach fame) immediately launched the Yale-Storrs controversy. He complained that Yale's entrance examinations required Latin, arithmetic, geometry, and trigonometry. "How many farm boys", he asked, "have the time to fit themselves for such an examination?"

Whatever examination the new Storrs Agricultural School used, the institution expanded rapidly during the 'eighties. When the Hatch Act passed in 1887, the Storrs school saw an opportunity to get more money, and Hale and the Grange tried hard to persuade the General Assembly to give Storrs the money to establish its own experiment station. The Grange didn't have enough political clout to do this, but it did have enough to get half the funds. Thus was born the second experiment station in Connecticut, and thus was more complexity added to the agricultural situation in the State.

The power of the Storrs Agricultural School continued to grow.

The school and the Grange fixed their eyes on the Land Grant charter held by Yale. They had obtained half of the Hatch Act: why not go out for the Land Grant Act as well? They went for it, and they got it. On April 21, 1893, just twelve years to the day after the act creating the Storrs Agricultural School, the General Assembly passed an act that changed the name to the Storrs Agricultural College and transferred the Land Grant charter from Yale to it.

According to Stemmons, Yale fought the transfer bitterly but lost. It is interesting to note that Dartmouth and Brown lost their Land Grant charters but others, like Rutgers and Cornell, did not.

Well, then we had two Agricultural Experiment Stations in Connecticut. How can they survive, what does each do, how do they avoid conflict? Stemmons comments: "on February, 1888, the Board of the Storrs Agricultural School appointed a committee" to prepare plans for experimental work and to confer with the Board of Control of The Connecticut Agricultural Experiment Station to obtain "harmony of work." On March 27 of the same year, they appointed Wilbur Atwater, S. W. Johnson's student and professor of chemistry at Wesleyan University, as their first Director. The Grange had objected to having their agriculture associated with a "classical University," and yet Storrs appointed a professor from a classical university as first Director of its Station. An agreement was made that field experiments could be carried out on the school farm at Storrs while 'more purely scientific investigations' were to be carried on in the chemical laboratory at Wesleyan.

Atwater resigned six months later. On October 1, 1888, he moved to Washington to organize the Office of Experiment Stations in the USDA. Stemmons says: "As Professor Samuel Johnson continued as trustee of the Storrs Agricultural School and Dr. Atwater had early been appointed to the Board Of Control of The Connecticut Agricultural Experiment Station, there was a close relationship between the two Stations in spite of the feeling that had occurred over the Hatch Act."

Stemmons goes on to say: "In 1902 there came a definite but not an absolute break with Wesleyan." Ambitions were again stirring at Storrs, and there was some resentment at having the experiment station work directed from Middletown. Atwater ceased to be Director in September 1902, and L. A. Clinton was made director. The two continued to cooperate until 1904. In 1912, when Clinton resigned as Director at Storrs, the Storrs Board appointed Dr. Edward H. Jenkins, by then Director of the Station in New Haven, to replace him. Stemmons commented, "The appointment of one director for the two Stations was intended to further insure harmony of purpose and to prevent duplication of effort." From the beginning there had been a tendency to specialize at Storrs in problems of animal industry and to leave the plant work to the New Haven Station. While it has been obviously impracticable to make this division of responsibility absolute, it has continued to form the basis on which the programs of the two stations are coordinated. In 1923 William L. Slate moved to New Haven from Storrs to become Director of both Stations. Stemmons says that "the two Stations have continued to grow in prestige and effectiveness under his management." And thus ends Stemmons's 1931 history of the two Stations.

THE TALE OF TWO STATIONS SINCE 1931

In 1936, Storrs got a new President, Albert Jorgensen, whose first move was to change the name to the University of Connecticut. The next stage in the Tale of Two Stations occurred in 1947, when Slate retired because of ill health and Horsfall was made director. At that time, Jorgensen staged a strong effort to absorb the Station. When this reached the ears of Governor McConaughey, who was Chairman of the Station's Board of Control, he ruled that The Connecticut Agricultural Experiment Station was too distinguished an institution to be moved around. That ended the episode but did not kill the issue.

In the fall of 1948, Chester Bowles was elected Governor. As he was a businessman, he thought it would be a good idea to run the State like a business. Among a large number of his proposals was one to move the Station to Storrs. At the legislative hearing, the members of Connecticut Garden Clubs swarmed to the Station's defense. Anne Conover, president of the Federated Garden Clubs of Connecticut, rose and proclaimed, "You can't move our Experiment Station!" And they didn't.

After that, things ran smoothly until Dr. Waggoner had to stave off another brief episode in 1971.

The last episode occurred in 1982. I report this despite my promise in the main body of this history to end the book with the end of the Station's first century in 1975. This episode is briefly mentioned in Chapter 2, "The Soul of the Station." Several years before 1982, the General Assembly passed the so-called Sunset Law, which specified that every small state agency must undergo an inspection every five years to see if it still performed a useful function. In 1982 the Station was duly examined. The General Assembly not only confirmed the status of the Station, it also broadened its charter as a public corporation and exempted it from future periodic examination.

At this point I will close out the tale of two stations and express my confidence that the New Haven Station will continue to be "too distinguished" to be tampered with.

Appendix I

SUMMARY OF HIGH HONORS TO STATION STAFF

This appendix lists the recognition that has been given to the Station staff during the first century of its life.

Membership in the National Academy of Sciences

Membership in the National Academy of Sciences is about the highest honor to which an American Scientist can aspire. It was established by Congress in 1863 by President Abraham Lincoln to advise him about technological problems during the Civil War.

Eight members of the Station staff have been elected as follows: S. W. Johnson 1866 (aged 36), T. B. Osborne 1910, L. B. Mendel 1913, G. P. Clinton 1930, D. F. Jones 1934, H. B. Vickery 1943, J. G. Horsfall 1953, and P. E. Waggoner 1978.

Two members of the Board of Control have been elected: W. H. Brewer 1880 and E. W. Sinnott 1936.

Eight former staff members have been elected to the Academy: R. Thaxter 1912, H. P. Armsby 1920, E. M. East 1925, P. C. Mangelsdorf 1945, D. H. Bodenstein 1958, Oliver Nelson 1972, A. Kelman 1976, and G. A. Zentmyer 1978. Douglas Waterhouse, a one-year visiting entomologist from Australia was elected as a Foreign Associate circa 1984.

Members of the American Academy of Arts and Sciences

The following staff members have been elected to the American Academy of Arts and Sciences: S. W. Johnson, T. B. Osborne, L. B. Mendel, G. P. Clinton, D. F. Jones, R. B. Friend, H. B. Vickery, J. G. Horsfall, P. E. Waggoner, and I. Zelitch.

Presidents of Scientific Societies

S. W. Johnson	American Chemical Society	1877
	Association Official Agricultural Chemists (First President)	1884
	American Association Agricultural Colleges and Experiment Stations	1896
E. H. Jenkins	Association Official Agricultural Chemists	1896
A. H. Winton	Association Official Agricultural Chemists	1896
L. P. Street	Association Official Agricultural Chemists	1906
E. M. Bailey	Association Official Agricultural Chemists	1930
H. J. Fisher	Association Official Agricultural Chemists	1953
E. M. Bailey	American Feed Control Officials	1934
	(Life Member)	1945
W. F. Britton	Association Economic Entomology	1908
G. P. Clinton	American Phytopathological Society	1912
J. G. Horsfall	American Phytopathological Society	1951
A. E. Dimond	American Phytopathological Society	1964
T. B. Osborne	American Society Biological Chemists	1910
H. B. Vickery	American Society Biological Chemists	1949
C. I. Bliss	Biometric Society	1961
D. F. Jones	Genetics Society	1935
E. R. Hanson	Phytochemical Society	1972
J. G. Horsfall	Society of Industrial Microbiology	1954
S. Rich	Society of Industrial Microbiology	1965

Honorary Doctorate Degrees

T. B. Osborne	Yale University	Dsc	1910
L. B. Mendel	Rutgers University	Dsc	1930
W. F. Britton	University New Hampshire	Dsc	1930
D. F. Jones	Kansas State College	Dsc	1947
J. G. Horsfall	University Vermont	Dsc	1958
	Turin (Italy)	DAgr	1964
	University Arkansas	LLD	1969
H. B. Vickery	Yale University	Dsc	1947
	Dalhousie, Nova Scotia	Dsc	1973

Fellows of International Scientific Societies

C. I. Bliss	*Societe Adolphe Quelelete* (Belgium)	1953
D. F. Jones	*Societa Italiana di Genetica* (Italy)	1956
J. G. Horsfall	*Societa Italiana di Fitoatria* (Italy)	1956
	Ordre Merite Agricole (France)	1970
	Indian Phytopathological Society	1966
C. I. Bliss	Royal Statistical Society (England)	1962

Science Honors World Wide

G. P. Clinton	International Shade Tree Conference, Treasurer	1929
A. E. Dimond	International Shade Tree Conference, Author's Citation Plaque	1971
	IX International Botanical Congress, Bronze Medal	1969
	International Congress of Plant Pathology, Honorary Member	1968
J. G. Horsfall	International Congress of Plant Pathology, Honorary Member	1960

Gold Medals

T. B. Osborne	Paris Exposition	1900
	John Scott Medal of Philadelphia	1922
	American Association Cereal Chemists	1928
L. C. Curtis	American Seed Trade Association	1949
D. F. Jones	Massachusetts Horticultural Society	1952
R. A. Jaynes	Massachusetts Horticultural Society	1973

Who's Who

A. E. Dimond	Who's Who in the East	1970
R. J. Lukens	Who's Who in the East	1970
P. E. Waggoner	Who's Who in the East	1970
J. G. Horsfall	Who's Who in America	1965
P. E. Waggoner	Who's Who in America	1971
J. G. Horsfall	International Who's Who	1969

Fellows of National Scientific Societies

G. P. Clinton	American Association Advancement Science	1920
J. G. Horsfall	American Association Advancement Science	1935
A. E. Dimond	American Association Advancement Science	1960
S. Rich	American Association Advancement Science	1974
C. I. Bliss	American Statistical Association	1948
P. E. Waggoner	American Society of Agronomy	1969
J. G. Horsfall	American Phytopathological Society	1965
A. E. Dimond	American Phytopathological Society	1966
S. Rich	American Phytopathological Society	1967
P. E. Waggoner	American Phytopathological Society	1970
R. T. Merwin	Association Official Agricultural Chemists	1968
H. J. Fisher	Association Official Agricultural Chemists	1967

Bronze Medals or Bronze Plaques

R. Beard	Association Economic Entomology	1939
N. Turner	Association Economic Entomology	1946
P. J. Anderson	Cigar Manufacturers Association	1951
H. B. Vickery	Cigar Manufacturers Association	1954
T. R. Swanback	Cigar Manufacturers Association	1965
G. S. Taylor	Cigar Manufacturers Association	1969
J. G. Horsfall	American Phytopathological Society	1972
	American Institute Biological Science	1974
W. O. Filley	Bronze Plaque on Boulder in Sleeping Giant State Park	1962
C. D. Clayberg	African Violet Association of America	1967

Scrolls from National or Regional Societies

D. F. Jones	Award American Seed Trade Association	1948
	Award National Garden Institute	1948
	District Service Award American Agricultural Education	1950
	Award New York Farmers' Club	1954
	Certificate Merit Botanical Society of America	1958
	Award of Honor, State Federation Garden Clubs	1962
C. L. W. Swanson	Stevenson Award American Society Agronomists (Youngest scientist to receive this award)	1952
R. A. Jaynes	Highest Honor Northern Nut Growers Association	1966
P. E. Waggoner	Outstanding Achievement Bioclimatology	1967
W. Norvell	First Emil Truog Soil Science Award (To the young Scientist who made the most outstanding contribution of the year for PhD thesis)	1971
R. A. Jaynes	James Jewett Award Arnold Arboretum	1972
H. B. Vickery	Stephen Hales Award, American Society Plant Physiology	1932
	Charles Reid Barnes Life Membership, American Society Plant Physiologists	1956

Honors Bestowed By Connecticut Organizations

G. P. Clinton	Connecticut State College Hall of Fame	1935
W. F. Britton	Connecticut State College, Honorary Recognition	1936
C. Remington	President, Connecticut Entomological Society	1949
R. Beard	President, Connecticut Entomological Society	1951
P. Garman	President, Connecticut Entomological Society	1953
J. P. Johnson	President, Connecticut Entomological Society	1955
J. B. Kring	President, Connecticut Entomological Society	1957
C. C. Doane	President, Connecticut Entomological Society	1961
S. W. Hitchcock	President, Connecticut Entomological Society	1967
D. E. Leonard	President, Connecticut Entomological Society	1966
J. Anderson	President, Connecticut Entomological Society	1969
R. C. Moore	President, Connecticut Entomological Society	1971
J. P. Johnson	Honorary Member, Connecticut Beekeepers Association	1952
J. C. Schread	Honorary Member, Connecticut Association Greenskeepers	1953
	Honorary Member, Conn. Golf Course Superintendents	1953
	Certificate of Achievement, Federated Garden Clubs of Connecticut	1959
P. M. Miller	Certificate of Achievement, Federated Garden Clubs of Connecticut	1970
S. Rich	Certificate of Achievement, Federated Garden Clubs of Connecticut	1971
J. Anderson	Certificate of Achievement, Federated Garden Clubs of Connecticut	1975
D. F. Jones	Award of Honor, Federated Garden Clubs of Connecticut	1962

Books Written by Staff

H. P. Armsby	*Manual of Cattle Feeding*	1880
A. L. Winton	*Microscopy of Vegetable Foods*	1906
T. B. Osborne	*The Proteins of the Wheat Kernel*	1907
	The Vegetable Proteins	1908
G. P. Clinton	*The Ustilaginales*	1910
D. F. Jones	*Selective Fertilization*	1928
J. G. Horsfall	*Fungicides and their Action*	1948
C. I. Bliss	*Statistics of Bioassay*	1952
J. G. Horsfall	*Principles of Fungicidal Action*	1955
S. Gould	*Authors of Plant Genera*	1965
	International Plant Index	1967
C. I. Bliss	*Statistics of Bioassay.* Vol. 1.	1966
	Statistics of Bioassay. Vol. 2.	1968
I. Zelitch	*Photosynthesis, Photorespiration and Plant Productivity*	1970
P. Day	*Genetics of the Host Parasite Interaction*	1971
R. J. Lukens	*Chemistry of Fungicidal Action*	1972
H. J. Fisher and F. L. Hart	*Modern Food Analysis*	

Editorships

J. F. Anderson and H. Kaya	*Perspectives in Forest Entomology*	1975
E. M. Bailey	*Critical Methods of Analysis,* 4th Ed.	1910
	Critical Methods of Analysis, 5th Ed.	1938
H. J. Fisher	*Critical Methods of Analysis,* 6th Ed.	
	Critical Methods of Analysis, 7th Ed.	
W. E. Britton, Editorial Board	*Journal Economic Entomology*	1910-1938
R. B. Friend	*Journal of Economic Entomology*	1929-1943
K. R. Hanson, Co-Editor	*Symposium, Phytochemistry in Relation to Disease and Medicine*	1975
J. G. Horsfall,	*Annual Review of Phytopathology*	1962-1972
J. G. Horsfall, Editorial Board	*Annual Review of Plant Physiology*	1956-1962
J. G. Horsfall and A. E. Dimond, Eds.	*Plant Pathology,* 3 vols.	1959-1961
J. G. Horsfall and E. B. Cowling, Eds.	*Plant Disease,* 5 vols.	1975-1978
G. H. Heichel, Editorial Board	*Plant Physiology*	1976
R. A. Jaynes	*Handbook of North American Nut Trees*	1969
D. F. Jones	*Board Genetics*	1926-1935
	Proceedings of the 6th International Congress on Genetics	1962
N. Turner	*Entoma*	1937-1943
	Misc. Publications Association Economic Entomology	1959-1963
H. B. Vickery, Associate Editor	*Journal American Chemical Society*	1935-1945
Editorial Board	*Journal Biological Chemistry*	1941-1968
Editorial Board	*Plant Physiology*	1951-1956
Advisory Board	*Biochemical Preparations*	1951-1971
Editorial Board	*Tobacco Science*	1958-1960
P. E. Waggoner	*Agricultural Meteorology*	1965
I. Zelitch, Editorial Board	*Plant Physiology*	1964-1968
Editorial Board	*Arch. Biochemistry and Biophysics*	1969-1977
Editorial Board	*Annual Review Plant Physiology*	1969-1974

OFFICERS OF THE BOARD OF CONTROL
Of the Connecticut Agricultural Experiment Station From 1877 to the Present

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T. S. Gold	1897-1905	John Lyman, Sr.	1951-1955
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H. W. Conn	1909-1917	Robert Josephy	1967-1971
James H. Webb	1918-1924	Warren E. Thrall	1971-1983
Charles R. Treat	1925-1928	Robert Josephy	1983-
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James G. Horsfall	1948-1971
Paul E. Waggoner	1972-1987
John F. Anderson	1987-

Literature Cited

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2. True, A. C. 1927. *A History of Agricultural Experimentation and Research in the United States 1607-1925*. USDA Miscellaneous Publications, 251:216-251.

3. Knoblauch, H. C., Law, E. M., Meyer, W. P., Beacher, B. F., Nestler, R. B., and White, B. S. 1962. *State Agricultural Experiment Stations: A History of Research Policy and Procedure*. USDA Miscellaneous Publications, 904. 362 pp.

4. Kerr, N. A. 1987. *The Legacy. A Centennial History of the State Agricultural Experiment Stations, 1887-1987*. University of Missouri Press. Colombia, MO, 318 pp.

5. Eliot, Jared. 1760. *Essays of Field Husbandry in New England As It Is Or May Be Ordered*. Boston, MA.

6. Johnson, S. W. 1869. *How Crops Grow*. Orange Judd and Company. New York, NY, 504 pp.

7. Day, P. R. 1969. (ed). *How Crops Grow a Century Later*. The Connecticut Agricultural Experiment Station Bulletin No. 708, 181 pp.

8. Carson, R. 1962. *Silent Spring*. Houghton Mifflin. Co., Boston, MA, 366 pp.

9. Osborne, T. B. and Mendel, L. B. 1918. The Growth of Chickens in Confinement. *Journal of Biological Chemistry*, 33:433-438.

10. Wallace, H. A. 1956. Double Cross-Hybrid Corn: A Story of Small Plots and Big Men. The Connecticut Agricultural Experiment Station, Circular 198:7-19.

11. Brown, W. L. 1987. Hybridum and Vigor. in Twenty Discoveries That Changed Our Lives. *Science 84*, November 1984.

12. Morgan, M. F. 1935. The Universal Soil Testing System. The Connecticut Agricultural Experiment Station Bulletin No. 372:457-483.

13. Stemmons, W. 1931. *Connecticut Agricultural College, A History*. Storrs, CT.