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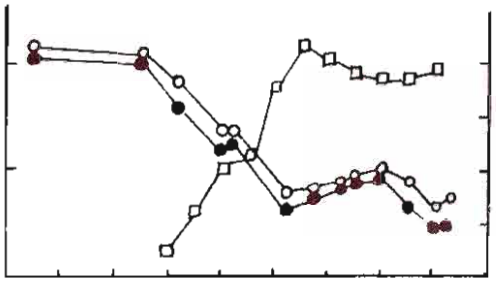

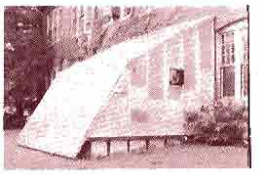

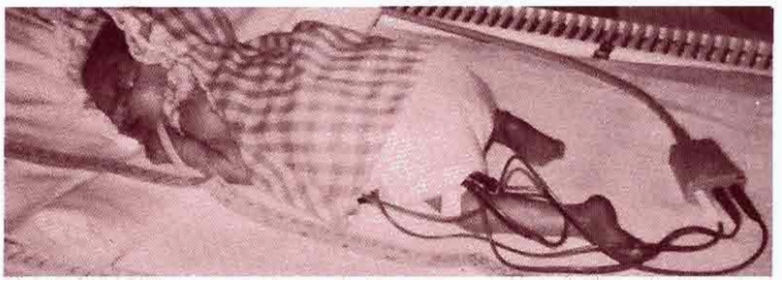

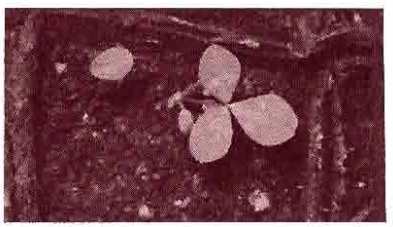

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Storrs Agricultural Experiment Station
The University of Connecticut, Storrs, Connecticut 06268

Research Report 69, August 1981

2 **Mother's Milk: A New Study of Human Milk Lipids**

6 **Kura Clover from the Caucasus**

10 **Research in Forest and Atmosphere Interactions**

14 **CEPG and GHSE Could Spell More Vegetable Production in New England**

18 **Searching for Answers: Studies in Genetic Control of Cartilage Development**

22 *Brucellosis:* **An Old Story Without an Ending**

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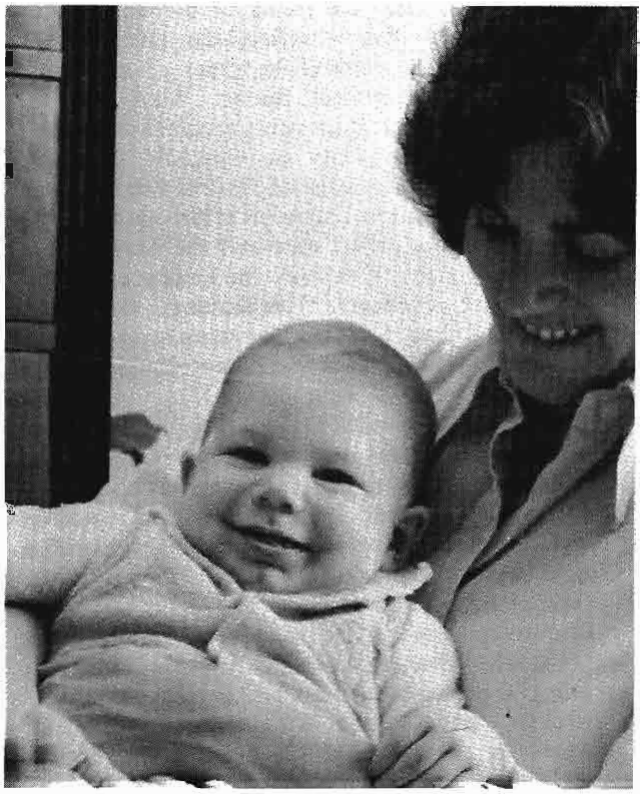
The articles and the listing of current research projects which follow reflect the diversity and relevance of the research program of the Storrs Agricultural Experiment Station. Moreover, the broad range of scientific talent required to conduct this research represents an especially important resource to the state; many of the staff also teach and some are engaged in Extension efforts as well. The Station is proud of its staff and the contributions which they make to enhance the quality of life for Connecticut residents. Furthermore, the many regional projects in which these scientists participate serve to broaden the research contribution of the Storrs Station.

At a time when much national attention is focused on scientific research in general, it seems appropriate to raise the question, What are the overall results of funds spent on agricultural research and extension services? Studies have shown that annual returns on investment in agricultural research are enormous, ranging from 25 to 55 percent. The proportion of disposable income spent on food is 13.6 percent in the United States, *the lowest* in the world. In Canada it is 15.3 percent, Australia 17.2 percent, Austria 19 percent, and United Kingdom 19.3 percent. Moreover, each dollar decrease in funds for agricultural research and extension raises the U.S. consumer's cost of food $6.14 over an 11-year period. And most important of all, agricultural research and extension have contributed, via increased agricultural exports, to solving our balance of payments problem. Our agricultural trade surplus is now about $25 billion. The non-agricultural trade deficit is about $50 billion. Thus, the agricultural trade surplus is offsetting 50 percent of the deficit in the non-agricultural sector.

These figures are proof of the effectiveness of agricultural research in the United States. It is our hope that this publication will provide an overview of the work of the Storrs Agricultural Experiment Station in this effort.

E.J. Kersting
Dean and Director



Mother's Milk: A New Study of Human Milk Lipids

Sandra Cookson

Dear Mother:

For most of human history, infants have been fed a food specifically designed for them — human milk. Surprisingly little is known about this food, however. Researchers at The University of Connecticut Department of Nutritional Sciences hope to fill in some of the missing data on the fat portion of the milk of mothers of full-term infants. Later we will analyze the same components from mothers of premature infants. Differences apparently exist in the composition of these two milks.

So begins the letter distributed from the offices of cooperating obstetricians in eastern Connecticut and through the La Leche league. It was the first step in the recruiting process which resulted in the collection of more than 300 samples of breast milk donated for this study by mothers at all stages of lactation. "Response was full and enthusiastic," reports Ann Ferris, one of the two principal investigators on the project.

In what Ferris describes as a natural partnership, she and Richard Clark of the University's Nutritional Sciences department have joined forces in a long-term study of the lipid (fat) content in human milk. By the end of 1980 they had a freezer full of meticulously documented milk samples lined up in labeled bottles, and frozen to −76C in the lipids laboratory freezer. Analysis of these samples is underway. Both Ferris and Clark came to the University as assistant professors in 1978. Ferris came from a clinical background in human nutrition, and is interested in nutritional problems of premature infants. Clark's training concerned the effects of nutrition on lactating dairy cattle; one of his interests is lipid metabolism.

Both were aware of the paucity of research into the composition of human milk and of human milk lipids, in particular. Ferris's clinical background and Clark's research emphasis clearly complemented one another. Furthermore, the facilities of the University's lipids laboratory and personnel, and the work of its director, Professor Robert Jensen, encouraged Ferris and Clark to undertake the study. They are enthusiastic about the advantages of an agricultural setting for their work. For years animal nutritionists have been analyzing the composition of cows' milk for nutrient value. Jensen thinks the comparative

neglect by nutritionists of human milk analysis is a matter of attitude. "Human milk is not considered as food," he observes.

This attitude is changing, however. The trend toward breast-feeding in this country has been increasing steadily since the 1950's, and seems likely to continue. With the recent endorsement by the American Academy of Pediatrics of human milk as the sole source of an infant's nourishment during the first six months, it is essential to gather baseline data on human milk composition. The recent initiation of

l. to r. Clark, Ferris, and Jensen in lipids laboratory.

several nationally supported research projects in this area is encouraging.

Since lipids supply more than 50 percent of the calories in human milk, they provide a ready source of energy for the tremendous demands of the growing infant. In this study, Ferris and Clark will concentrate on the analysis of three lipid classes: triglycerides, sterols, and phospholipids. Triglycerides are the source of calories and the essential fatty acids. Sterols are important in cellular composition, in the making of hormones, and the formation of Vitamin D^3, an antirachitic vitamin.

Cholesterol, phospholipids, and their associated fatty acids are structural components of membranes. Changes in their composition can alter the functional characteristics of the membrane and may be crucial during the first two years of life for the normal development of the brain and nervous system. The concentration of these lipids in human milk may be particularly critical for the premature infant who is rapidly synthesizing new membranes.

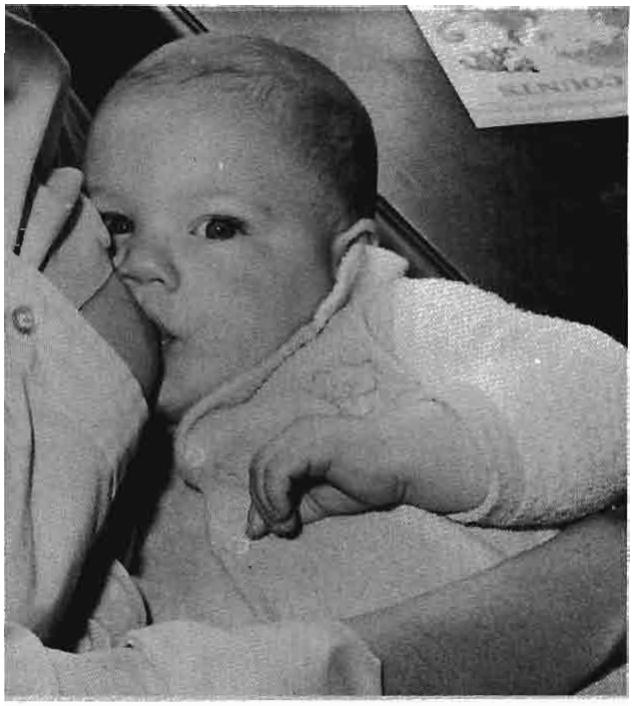
An understanding of the lipid requirements for the premature infant, who is at higher risk than the full-term infant, is critical. Currently, no data are available on the cholesterol and phospholipid content in the milk of mothers of premature infants. But preliminary studies have shown a higher lipid content in the milk of these mothers. This finding suggests that the added fat may be there in order to make up for the premature infant's deficit of adipose tissue for energy storage. The lipid in formulas fed to premature infants is not as fully digested as the lipid in human milk, Clark explains. He adds that we do not understand completely the reasons for this, but its implications for the premature infant who needs to add body fat quickly could be significant.

Previous studies have also shown a great variation in the composition of the milk of individual mothers, and a wide fluctuation in the lipid content of an individual mother's milk throughout the 24-hour period. These observations suggest that an individual mother's milk may be specially constituted to meet the needs of her own infant as these fluctuate during the day. However, poor sampling techniques used in the past and the general lack of knowledge about the composition of human milk may account for some of these differences.

Remembering the maxim that analytical results are only as good as the techniques used to produce them, Ferris and Clark developed a strict sampling protocol. They recorded dietary information. They verified the length of time between the infant's last feeding and the time the mother last smoked a cigarette or ingested caffeine. They established the times of day during which breast milk would be collected. A pre-sterilized electric breast pump (Egnell) was used for greater efficiency in emptying the entire breast. After the samples were measured and transferred to sterile labeled bottles, they were sealed and immediately frozen on dry ice in styrofoam containers. They were then transferred within four hours to the University's lipids laboratory freezer.

While strict sampling techniques were essential, it was just as important to gain the full cooperation of the women who would be asked to submit two samples of their milk on each of four visits to their homes by Ferris or one of her assistants. They would be asked to make a commitment to the study for about four months, since the first samples of their milk would be taken at two weeks postpartum and the final samples collected at sixteen weeks.

At several points in the preliminary stages of questions and interviews, a prospective donor had the opportunity to change her mind and decide not to participate. "We didn't lose a single one," Ferris notes proudly. The 100 percent participation rate was



probably the result of several factors. First, preliminary screening by the woman's obstetrician during the last month or so of her pregnancy ruled out health problems and established her initial interest in being part of the study. Thereafter, credit for the success of the recruiting effort must go to Ferris and her assistants whose thorough, enthusiastic, and extremely supportive attitude made the experience a valuable one for the women who participated in the project.

If Ferris and Clark find that differences do exist in the lipid composition of milk of mothers of premature and full-term infants, this information can be used for supplementing the infant's diet and for altering the premodified commercial formulas fed to premature infants.

Kura Clover: A New Legume for New England

D.W. Allinson, G.S. Speer, R.W. Taylor

Occasionally, in recent years, plant scientists have speculated about the agronomic potential of kura clover (*Trifolium ambiguum* Bieb.). Alternatively known as Caucasian, honey, and Pellett's clover, kura clover is not presently utilized as a forage crop in the United States and indeed has been subjected to only limited evaluation.

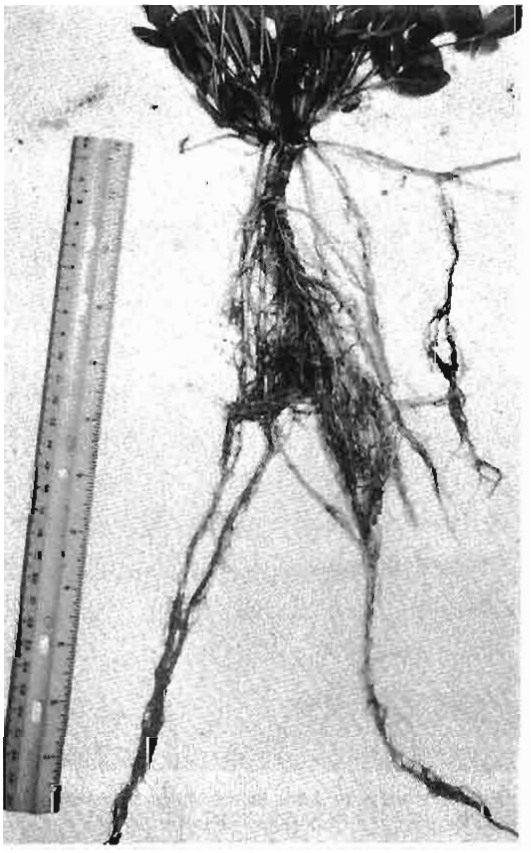
Kura clover is indigenous to Caucasian Russia, the Crimea, and Asia Minor (W.G. Bryant, 1974). It appears to have a wide range of adaptation, since it is found in river valleys, mountain slopes, and subalpine regions. Reports indicate that it is both winterhardy and drought tolerant and it appears to persist on both dry and moist sites, as well as in soils that are occasionally inundated with water. A polyploid series exists (L.W. Kannenberg and F.C. Elliott, 1962). Diploid, tetraploid, and hexaploid races occur, with somatic cell chromosome numbers of 16, 22, and 48, respectively. Kura clover resembles ladino clover (*Trifolium repens* L.) Both are herbaceous, possessing petiolate, trifoliate leaves. However, kura clover has a deep, branching taproot and is also strongly rhizomatous. Stems of kura clover may be either procumbent or upright and may grow to 24 inches in height. Flower heads may carry over 100 flowers, which are usually white in color, but which often have pink tinges. Flower color development, from white to pink to rose pink, appears to be associated with age since coloration often appears as flowers mature.

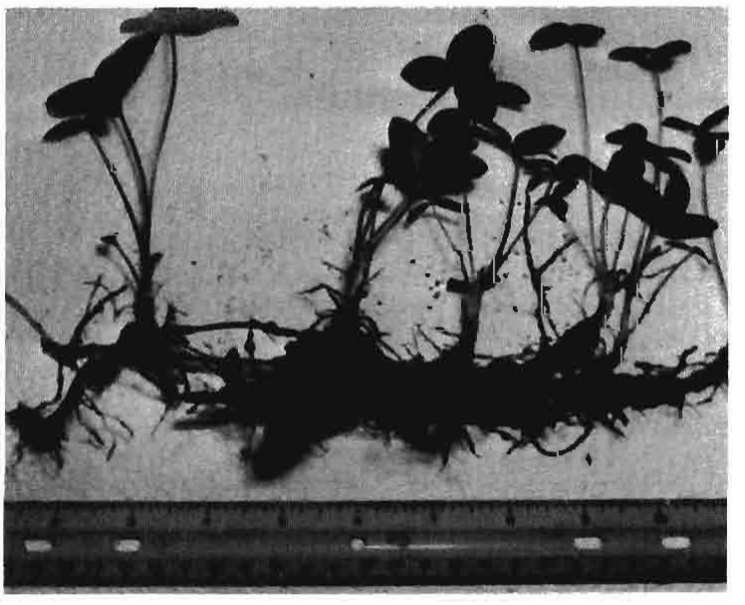
The perennial nature of kura clover, together with its other desirable agronomic characteristics, suggest that it could find substantial use as a forage crop in temperate climates. However, this species has not been introduced because of difficulties experienced with establishment and nodulation. Evidence in the scientific literature, though limited, would suggest that these difficulties can be overcome.

In early June 1978, kura clover, along with annual ryegrass, tall fescue, orchardgrass, redtop, reed canarygrass, Indiangrass, switchgrass, big bluestem, birdsfoot trefoil, alfalfa, ladino clover, milkvetch, big-flowered vetch, crownvetch, and red clover was

Professor of Agronomy, Graduate Assistant in Agronomy, The Univ. of Connecticut; Assistant Professor of Agronomy, Louisiana State Univ.; respectively.

D.W. Allinson (left) and G.S. Speer (right) remove a kura clover plant from a pot in order to examine root and rhizome development (see below).





seeded in the Valentine meadow, Storrs, Connecticut. This seeding, one of several that were made at a number of locations in the northeastern region, was part of a federally-funded cooperative regional research project entitled *Forage-Livestock Systems for Land with Soil and Site Limitations*. The purpose of this part of the project was to evaluate a wide range of plant materials for their adaptation and agricultural worth in sites which have some limitations insofar as plant growth is concerned. The northeastern region has several million acres of land with such agricultural limitations as poorly drained or infertile soil. The introduction of new species, adapted and productive, on these acres could have a substantial impact on the agricultural productive capacity of this land.

In the period between 1978 and 1981 a number of

Extensive root mass of kura clover showing several root nodules. Within these nodules bacteria fix gaseous nitrogen into a form used by the kura clover.

the species established in the study, including annual ryegrass, birdsfoot trefoil, red clover, ladino clover, crownvetch, milkvetch, and big-flowered vetch have either died out or are present in only nominal or uneconomic quantities. The soil in which the trial has been conducted is poorly drained. Although the soil was fertile at the initiation of the study, no fertilizers have been applied since. Nor have herbicides been used. Kura clover, which established slowly, has improved in stand density each year. It was not harvested for yield evaluations until 1980 when slightly over 2 tons per acre of dry matter were obtained. Laboratory assessments of the quality of kura clover, determined by using the *in vitro* dry matter digestibility (IVDMD) procedure, indicate that it is highly digestible. Over the three-harvest period used in 1980, kura clover had higher IVDMD values than other legumes such as alfalfa, red clover, crownvetch, and milkvetch.

The preliminary results from this adaptation study have been sufficiently encouraging to stimulate further systematic agronomic evaluation of kura clover. Percentage germination of kura clover was substantially increased by seed scarification with sulfuric acid. Similar results have been reported in the literature for mechanical seed scarification. This suggests that seeding establishment can be, if not enhanced, at least made more uniform.

Greenhouse studies indicate that kura clover plants are quite variable in appearance. However, they are consistently extremely rhizomatous, producing in a few months many plants from a single rhizome. In the establishment of kura clover plants major emphasis has been placed on root and rhizome development, and this emphasis on root and rhizome production is reflected in the literature. In one study the dry matter root plus rhizome/shoot ratio for kura clover varied from 2.4-3.7 while that for the stoloniferous white clover was approximately 0.2 (K. Spencer, F.W. Hely, A.G. Govaars, M. Zorin, and L.J. Hamilton, 1975). This discrepancy between below ground versus above ground biomass may account for the limited herbage produced during the establishment phase of this species. While this may be a limiting factor in considering kura clover as a forage, it may be an advantage in considering kura clover for erosion control.

In summary, kura clover appears to have potential for use as a perennial legume. It has demonstrated winterhardiness under Connecticut conditions and appears to have been effectively nodulated. Estimates of digestibility are high. Stand density is increasing under conditions where many other forage species have demonstrated a loss in stand density. It is very rhizomatous, a characteristic that has aided in the continued improvements in stand density. While these observations are promising, much is yet to be learned about kura clover.

Kura clover seedlings being grown in the greenhouse prior to being transplanted in the field.

Research in Forest and Atmosphere Interactions

D.R. Miller

We can see that the local environment affects forest vegetation and other organisms in the ecosystem. It is not so obvious but just as true that the forest and individual trees in the forest affect the physical environment around them. For example, heat is exchanged between trees within the forest

Associate Professor of Natural Resources Conservation

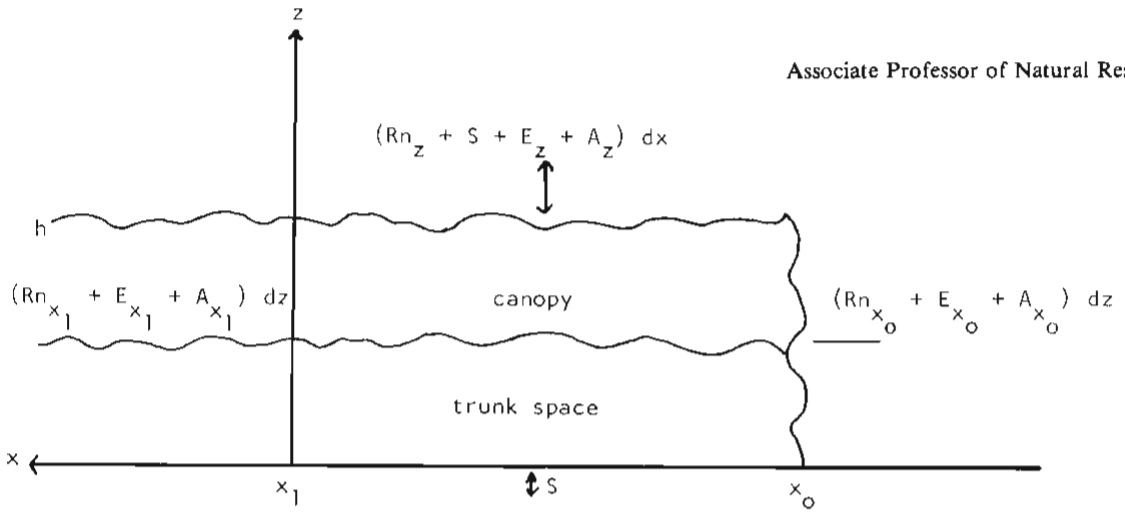


Figure 1. Diagram of the two-dimensional energy budget at a forest edge.

Figure 2.

canopy, between blocks of trees and adjacent urban areas, and between trees and the soil. Our ability to measure these exchanges and study them may help us better utilize energy in agricultural, urban, and forest environments.

Of equal importance are air-circulation patterns and surface energy exchanges that occur in valleys. These are the major processes controlling the temperature inversions which trap high concentrations of air pollutants in urban valleys and influence the buildup of cold air layers or frost pockets in valley bottoms. Frost pockets are a factor in determining energy use and agricultural practices. Changes in land use on valley slopes may have considerable impact on temperature inversions and on the flow of air through a valley. We know that height and type of vegetation have a significant effect on the development of gravitational movements of nocturnal air, called drainage flows.

The use of forests to modify the environment has been studied at The University of Connecticut for a number of years. Through this research we have succeeded in modeling and measuring the canopy-atmosphere exchanges of sensible heat, latent heat (water vapor), and radiation. These studies with individual trees (Stark and Miller, 1975; Miller and Federer, 1977; Christensen, 1979; Miller et. al., 1980) and with blocks of trees (Miller, 1976, 1978, 1980; DeVito, 1978; DeVito and Miller, 1977) have defined the two-dimensional (horizontal and vertical) energy exchanges of trees and groups of trees with surrounding environments. These findings are currently being integrated spatially into models in order to study the influences of vegetation on the flow of air through a valley.

Forest Edge Effects

Horizontal energy transport or advection is a major source of confusion when defining the physical interaction between vegetation blocks and adjacent areas. If small blocks of trees have an effect on the local energy balances beyond their shading reach, then there must be a significant horizontal energy exchange between the trees and adjacent areas. The complex, three-dimensional form of the forest, urban, and agricultural interface, and the large amounts of sensible heat produced in urban settings suggest that horizontal advection into the edges of trce stands may be significant.

We have approached this problem by using a box model to describe the horizontal and vertical energy fluxes to a stand of trees at the forest edge. The energy exchanges of a cross-section of forest located at a stand edge are diagrammed in Figure 1. The forest exchanges radiation (Rn), latent heat (E), and sensible heat (A) both vertically ($_Z$) and horizontally

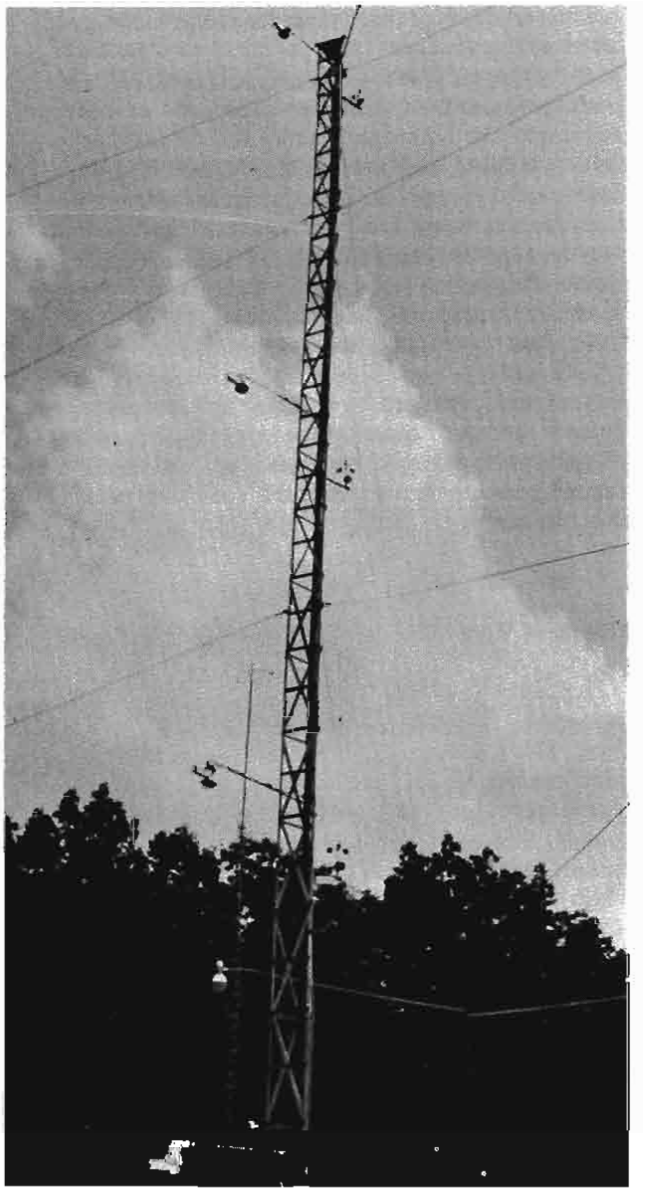


Figure 3.

($_X$) with the surrounding atmosphere. There are also horizontal and vertical exchanges of these entities within the canopy. At the lower boundary heat is exchanged with the soil (S).

We have calculated (Miller 1979, 1980) the terms of the energy balance illustrated in Figure 1 from field measurements of temperature, humidity, wind, and radiation (Figures 2 and 3). Rn_X was calculated from a field determined atmospheric transmission coefficient and a regression of measured solar radiation (R_S) on R_n. Rn_Z and S were measured direetly. E_Z and A_Z were estimated by splitting between them the net energy available to the edge volume. The division between E_Z and A_Z was in proportion to the ratio of the vertical temperature and vapor pressure gradients above the forest canopy.

The variations of the flux terms within the "box" at increasing distanees from the stand edge have not been completely defined. But exponential decay relationships have been developed. The rates of decay still need to be defined as functions of the stand edge density and the edge momentum balance. The two-dimensional energy budget calculations indicate that the additional Energy, radiated and advected horizontally through the edge, is dissipated by increasing the evapotranspiration rates of the trees and by rising vertically through the canopy.

To date these studies have demonstrated the importance of the horizontal transport proeesses. We are currently involved in defining and testing turbulenee models to quantify the horizontal transport of momentum across forest edges as a function of the canopy geometry and atmospheric conditions at and near the edge.

Effects of Vegetation on Slopes

Frequent calm, elear nights together with abrupt topography produce extreme local climatic conditions. The intensity and persistence of valley frost pockets and inversions are related to windspeeds, air temperatures, and intensity of nighttime radiational cooling. Radiation loss from the surface cools the surfaee and then the adjacent air by conduction, which in turn increases the relative humidity. With substantial cooling, condensation may occur.

Figure 4 demonstrates the interactions between net radiation loss, surface temperature drop, and frost formation caused by condensation. It graphs the course of surfaee temperature and the net radiation loss in a pine-forested mountain valley. The canopy surfaee temperatures cooled at a rate of approximately − 2C per hour and the net radiation loss rates decreased steadily. Then frost began forming on the trees as surface temperature dropped below freezing. The release of latent heat because of condensation and freezing of water ended further surface cooling and net radiation loss until just before dawn.

On a sloping surface the cooling process is accompanied by a gravitational flow of the cooled air (cold air drainage). The movement of the cool air along the slope and the layering of the cold air in pockets and valleys greatly increase the total air cooling potential and relative moisture content. These processes affect the length of the growing season, the moisture content of forest fuel, the dispersal of pathogenic spores, heating requirements of buildings, and eoncentrations of air pollutants. Little information is available about the motion and development of eold air drainage. In particular, we know very little about the development of air flow over and through vegetation canopies.

We are currently analyzing these valley flow systems to determine if hillside vegetation and manmade structures can be managed to control the cold air flow processes. Our first study examined the flow of cold air drainage over three surfaces: corn, oak forest, and bare ground. We compared the actual

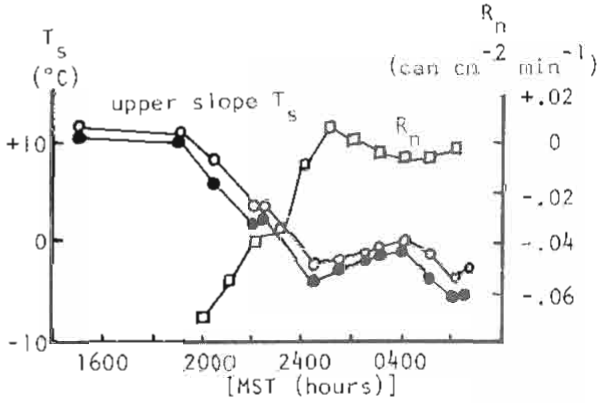


Figure 4. Surface temperatures and net radiation losses.

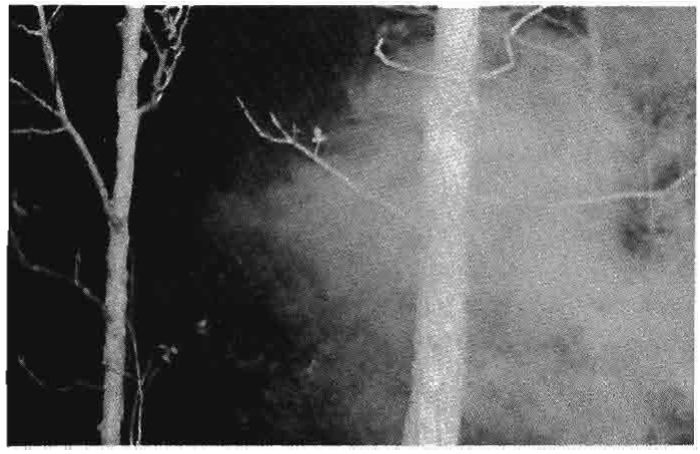


Figure 5.

flow patterns to those described by theoretical models. Smoke tracers (Figure 5) and vertical profiles of wind and temperature showed drainage flow development and retention to be markedly affected by surface cover. Current theoretical models of valley flows were found inadequate for use with tall vegetation.

In order to combine the effects of vegetation on the components of cross-valley circulation with the overall valley flows as a three-dimensional problem, we conducted a field study in a pine-forested valley in eastern Arizona. It was done in cooperation with the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station — Mountain Meteorology project; and has been described by Miller and Bergen (1981). We monitored a cross-section of a valley to measure surface air temperatures, wind speeds and directions with remote weather stations (Figure 6). Vertical profiles of wind and temperature, radiation balances, and inversion heights were also measured.

The major effect of forest vegetation on the development and maintenance of valley drainage flows appears to be increased drag on the movement of flows. Also, protection of the ground level slope flows from disruption by wind penetrations from above, and some effect on the locations of temperature inversions may be significant. Theoretical models are currently being developed from this study (Bergen, Miller, and Neroth, 1981).

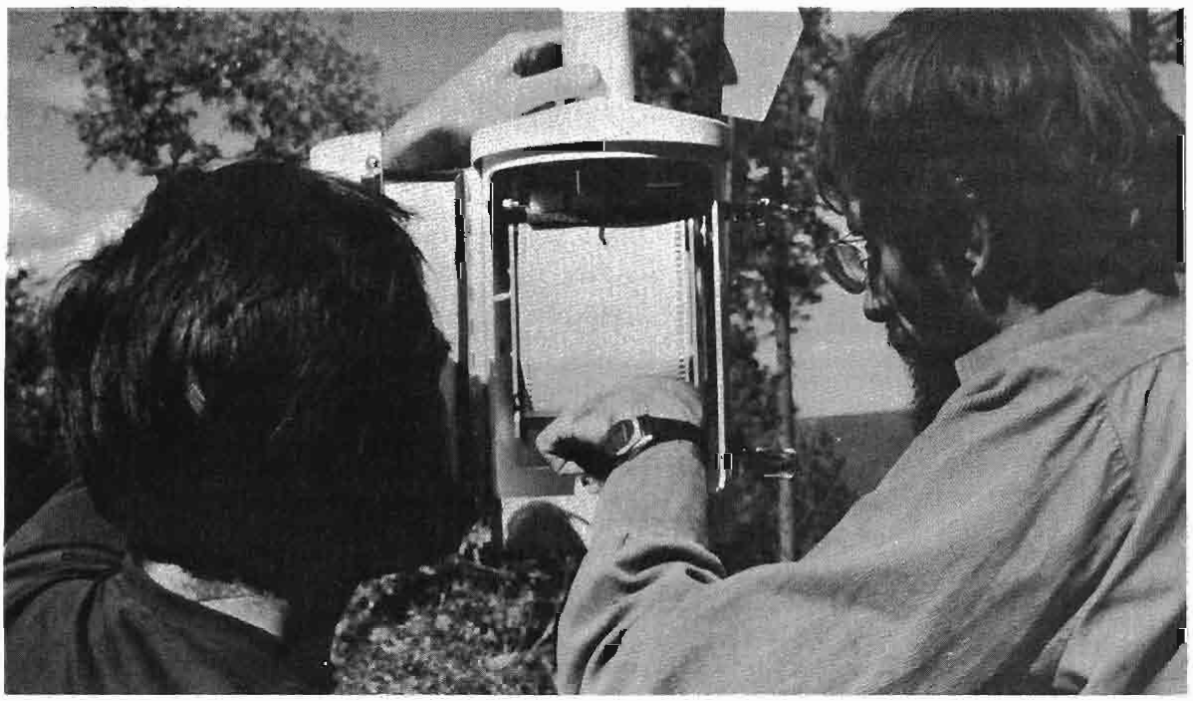
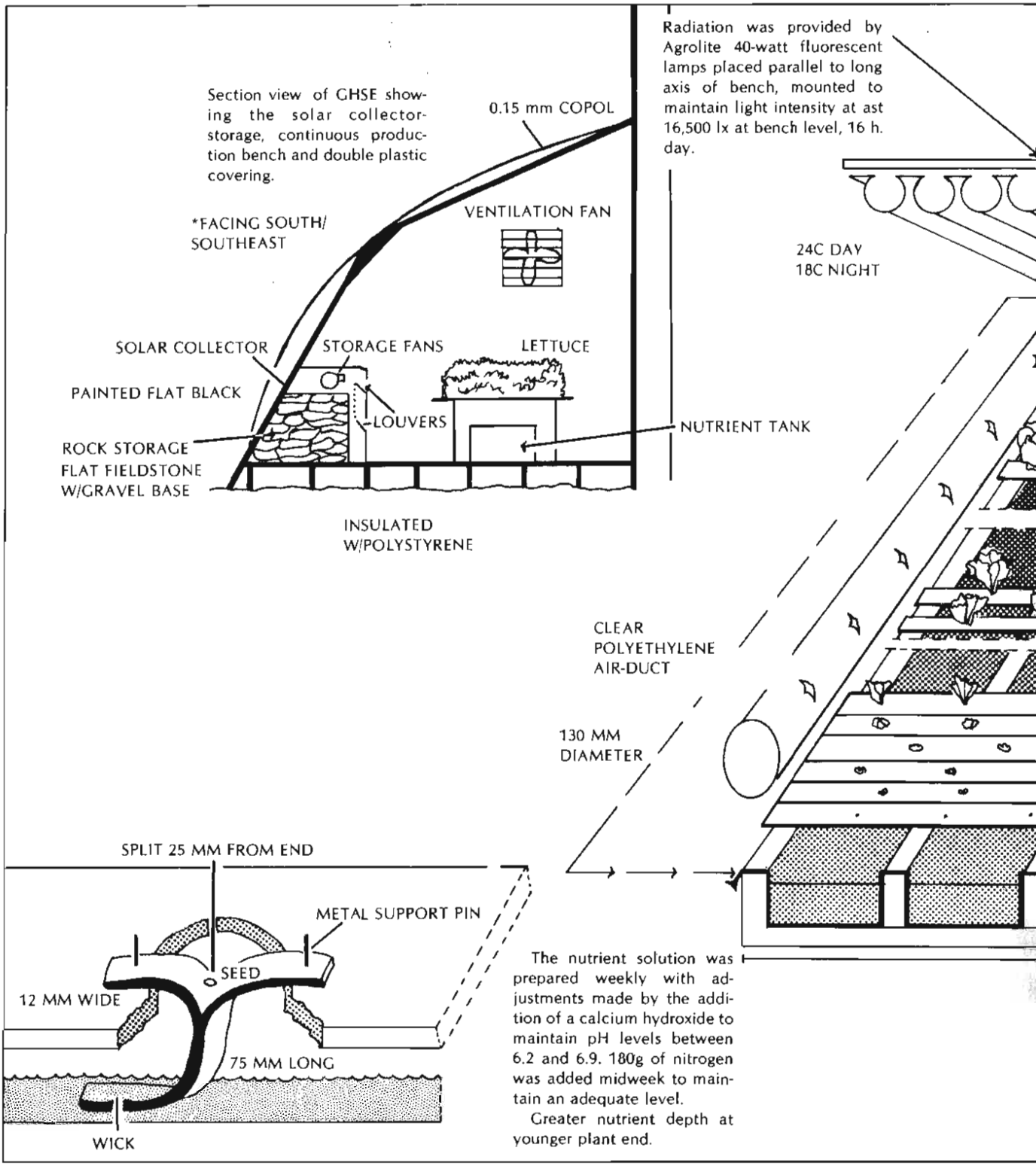


Figure 6.



The nutrient solution was prepared weekly with adjustments made by the addition of a calcium hydroxide to maintain pH levels between 6.2 and 6.9. 180g of nitrogen was added midweek to maintain an adequate level.

Greater nutrient depth at younger plant end.

CEPG and GHSE Could Spell More Vegetable Production in New England

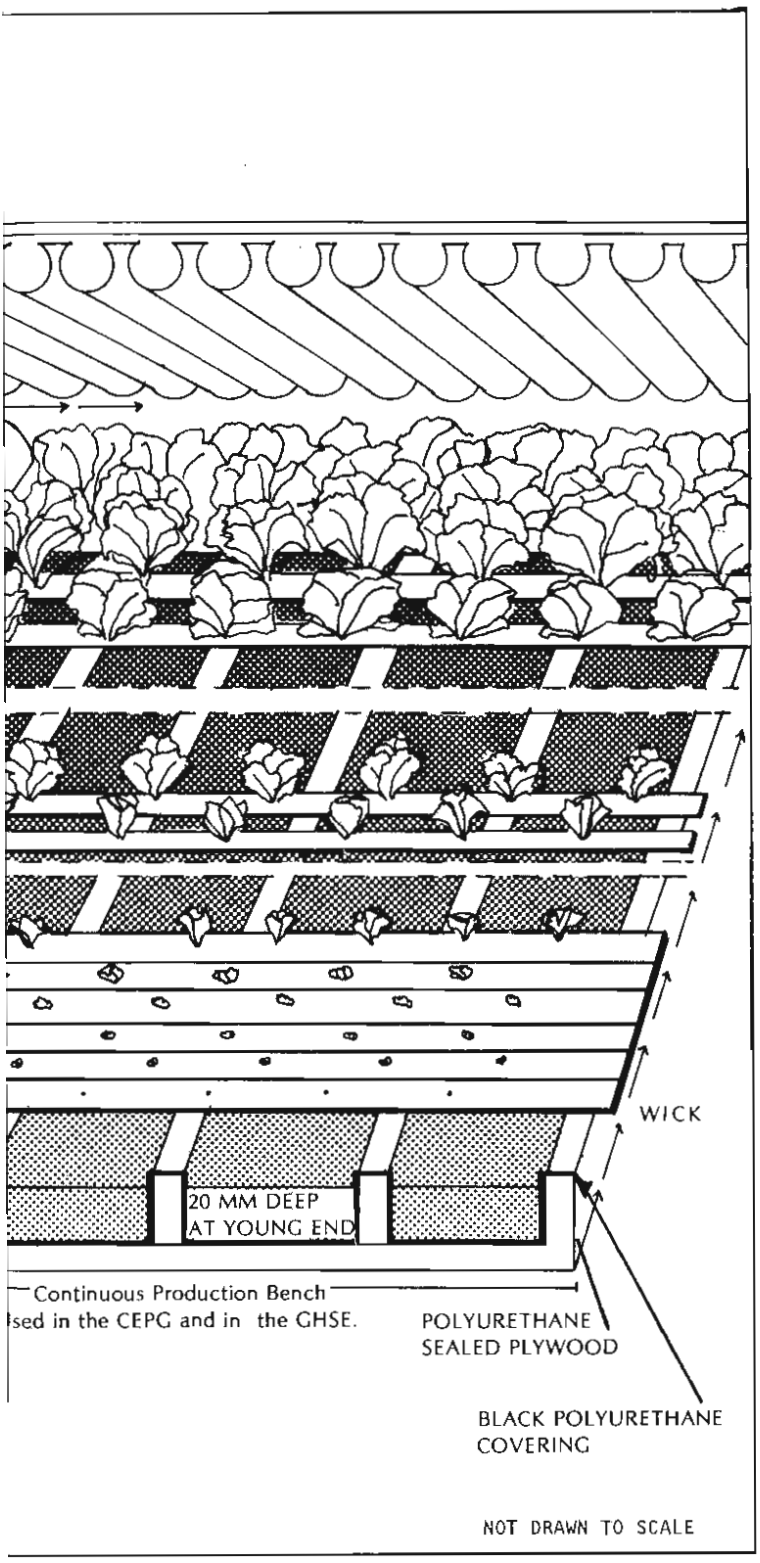
R.P. Prince, J.W. Bartok, D.W. Protheroe

New England imports approximately 85 percent of the vegetables it consumes. The vegetable growing season of generally less than five months makes it impossible to maintain a continuous supply of locally field-grown fresh vegetables throughout the year.

Our principal objective in this project has been the development of the components necessary for efficient vegetable production in an entirely artificial soilless environment. Greenhouses offer a means for year-round crop production at any location, provided there is sufficient heat and light to support acceptable growth. Since both are limited in New England during the winter months, we have developed a hybrid system combining the use of artificial light in a specially designed "growth room" with a solar assisted greenhouse as a way to maintain uniform production during these months.

This integrated growth room-greenhouse system concept utilizes a Controlled Environment Plant Growth (CEPG) unit and an energy efficient greenhouse (GHSE). A controlled environment plant growth (CEPG) facility has the potential for efficient use of energy and space during germination and early growth stages. A greenhouse demonstrating proven thermal energy conservation practiees, including solar thermal energy collection, can also make use of excess heat from lamps and ballast in the CEPG unit. The net result may be an efficient system in terms of energy used per unit of vegetable produeed.

The experiment described here involved the construction of a growth room and a greenhouse integrated for the production of two types of leaf lettuce, Grand Rapids and Ostinata. New England's 14 million residents consume nearly 600 metric tons (1 metric ton = 2,204.6 lbs.) of leaf lettuce annually. Previous work at The University of Connecticut and elsewhere has provided baseline data on light, temperature, moisture, CO^2, and nutrient requirements for artificial production of lettuce.



Professor, Associate Research Professor, and Research Assistant in Agricultural Engineering, respectively.

achieve high plant densities and maintain good growth. In operation, daytime for the CEPG unit was actually night. During these nighttime hours, heat from the lamps was transported by warm air to the GHSE, providing maximum energy use.

Greenhouse

A wood-frame greenhouse with a gravel floor was attached to the south side of the Agricultural Engineering building on the University campus. The greenhouse was covered with two layers of copolymer plastic, air separated, using a blower. Polystyrene insulation was placed around the foundation wall and used to insulate both end walls. A fan was installed for ventilation.

Solar Collector/Storage was provided by a rock wall unit built into the lower front of the greenhouse, facing south-southeast, constructed of flat field stone, and laid on a gravel base. The top, sides, and back were insulated with polystyrene; the south face was spray-painted flat black. Three blowers were mounted above the unit to circulate air within the collector/storage or transfer heat from the storage to the greenhouse. A system of motor-operated louvers directed the air flow.

A Heat Transfer Unit collected heat from the CEPG unit and transferred it to the greenhouse. The system was composed of two blowers, PVC pipe, and a sheet metal hood. A blower mounted above the lamphood moved air through the PVC pipe to the greenhouse. A 3 kW electric resistance space heater with blower was used to supplement the other systems.

A Control System was developed, using thermostats, thermisters, and relays. Sensors for detecting temperature changes in the greenhouse were located above the bench at plant height. A silicon cell activated the storage blowers when there was sufficient radiation.

Controlled Environment Plant Growth Unit

The CEPG lettuce unit consisted of a continuous production bench under artificial light and in an environmentally-controlled room. The GHSE was fitted with the same type of bench. This bench employed constant nutrient film solution flow with provision for advancing all plants along the bench daily and modifying their spacing at specific times to

Lettuce Production

Approximately 40 seeds were placed on a moist white paper towel in a petri dish for 24 hours. Each day two growth strips were seeded with two germinated seeds in each of seven wicks per strip. The strips were placed on the CEPG unit and covered with black plastic. One strip of seven plants was removed from the CEPG unit on the 16th day and placed on the continuous production bench in the GHSE. The matching strip of seven plants remained in the CEPG unit. The growth cycle for the plants in the CEPG unit was 35 days and for those in the GHSE 42 days, with a shorter growing period observed in the GHSE during late spring. A 5-step spacing

schedule was used for both the GHSE and the CEPG unit.

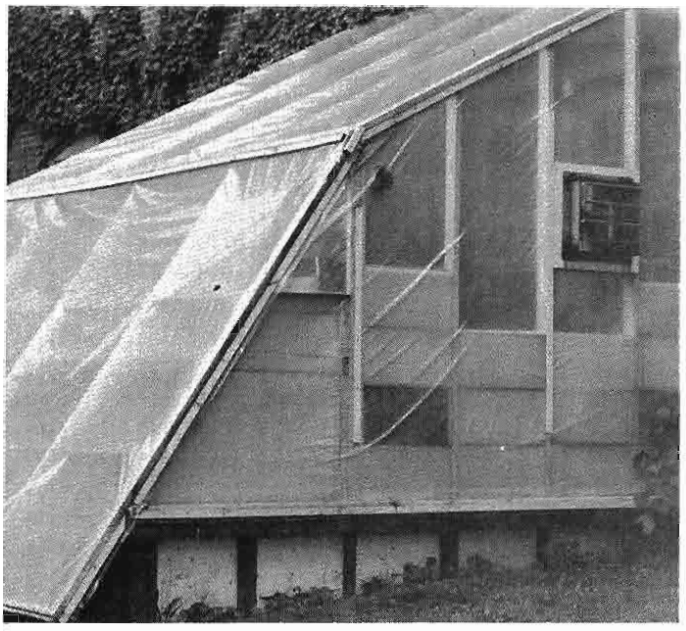
Daily measurements on harvested plants were made of green foliage, root, and bad leaves mass. Plant height and diameter, temperature, pH, total moisture condensed, nutrient flow rate and conductivity were likewise measured each day. Plant diameter was determined by inverting the foliage portion and averaging at least two measurements across the plant. All roots were centrifuged at very low force for 6 seconds to remove surface water.

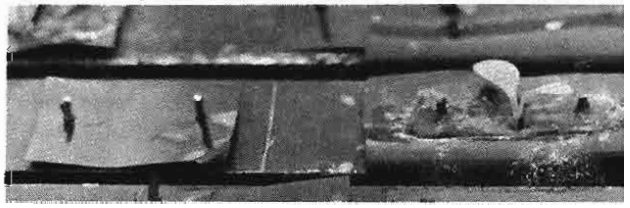
The total yield of Grand Rapids and Ostinata lettuce for one 120-day test period during which plants were harvested daily was 102.3 kg. Over the 76-day harvest, yield of Grand Rapids in the growth room was 39.2 kg and in the greenhouse 17.5 kg for nearly an equal number of plants. Yield of Ostinata during the 44-day test was 25.5 kg in the growth room and 20 kg in the greenhouse. Plant loss was negligible. Loss in plant material was measured in terms of 1) loss of root material at harvest, which amounted to 12 to 18 percent of the green edible mass; 2) loss of leaves at harvest, which amounted to about 10 percent of the edible mass; and 3) mortality of the total plant during the growth period, which amounted to 30 percent in some test periods. The measurements of plant diameter and plant height showed that both varieties tend to take the total area available to each plant.

Results and Discussion

Lettuce plants have a relatively high temperature requirement of 15.6C. On sunny days in March and April of 1979, the rock wall solar collector/storage was able to provide more than 40 percent of the heating needs. During January and February, however, the contribution to heating requirements was minimal. The simple heat transfer system proved effective since it reduced the amount of refrigeration needed to maintain desired temperature in the growth room.

The greenhouse gained additional heat during the day because it was attached to the Agricultural Engineering building which has an uninsulated red brick wall 30.5 cm thick. On sunny days the wall temperature in the greenhouse area reached as high as 26C. This provided some storage and some heat transfer to the building. Based on the results of one typical clear/cloudy cold day, the heat saved by the greenhouse over the 8-hour period amounted to approximately 62,700 kJ.





The heat available from the two light banks with an input of 2400 watts was 8,650 kJ/h. Assuming an average intake temperature of 35C at the hood and a heat loss in the transfer pipes of 500 kJ/h, approximately 4500 kJ/h was available to heat the greenhouse with the system that was installed. This provided about 15 percent of the heat needs on the coldest night and a greater percentage on warmer nights.

The storage/collector system was most effective with the blowers operating continuously to circulate heat during the collection phase. Although circulating the air transferred the heat from the front of the rock wall to the rear, the air movement might have increased heat loss through the face at night. A slight reduction in heat loss from the storage face could have been obtained by using fiberglass-reinforced plastic (FRP) rather than polyethylene, which allows a greater amount of radiant energy to pass through. A further reduction could have been obtained by using an insulating panel over the storage face at night.

Two modifications that might be made to the collector/storage system to increase its contribution to the heating of the greenhouse are 1) the use of a variable size storage so that satisfactory temperatures could be obtained throughout the year; and 2) varying the size of the collector, possibly with reflectors, to increase the collection potential during the winter months. In either case the volume or area should vary with the amount of insolation available.

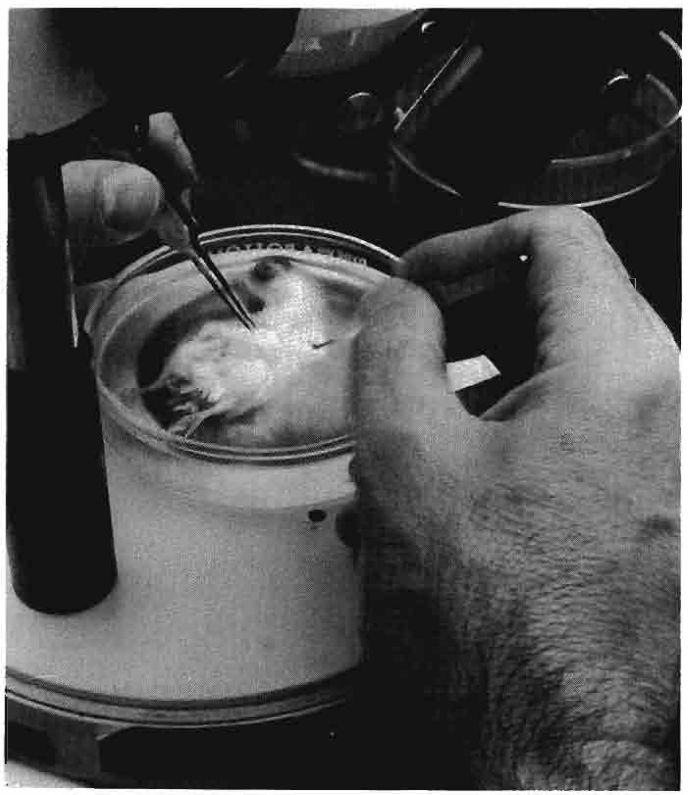
Searching for Answers: Studies in Genetic Control of Cartilage Development

Sandra Cookson

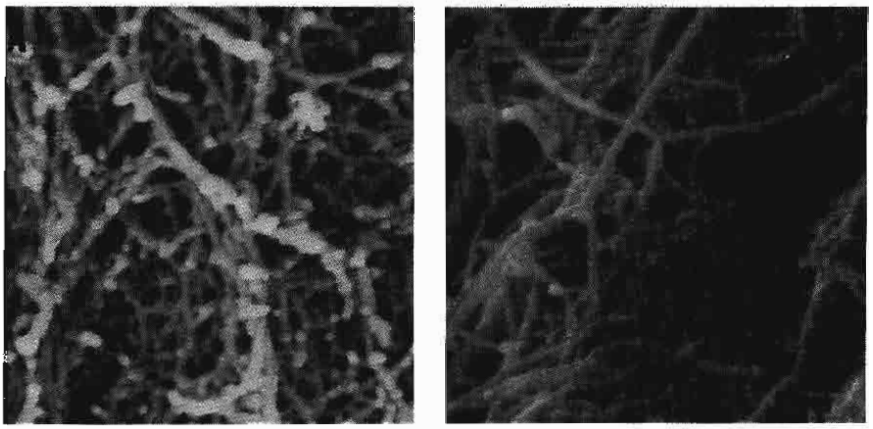
With the aid of a unique collection of chick embryo mutants, the only one of its kind in the world, Dr. Paul Goetinck of the Department of Animal Genetics is studying the genetic control of connective tissue development. The collection of mutants was developed and maintained for work on limb development by Dr. Walter Landauer, an eminent poultry geneticist, who served on The University of Connecticut faculty from 1924 to 1964. Under Hatch Funds and National Institutes of Health grants, Dr. Goetinck and his co-investigators are examining the developmental processes in normal chick embryos and in two types of mutants with connective tissue abnormalities. Both mutants are characterized by shortened limbs and parrot-like beaks. Though the two mutations are genetically distinct, each phenotype is inherited as a simple recessive trait.

In a recent paper on the study, presented at the 39th Annual Symposium of The Society for Developmental Biology, held at Storrs in June 1980 and dedicated to Landauer, Dr. Goetinck explains that the current study represents a continuation of Landauer's work on the genetic control of development. Accordingly, Dr. Goetinck's studies are being carried out on both normal and mutant embryos, using the methods of the geneticist, the embryologist, and the biochemist — the combined approach Landauer recommended.

Cartilage is the firm, elastic, flexible, supportive connective tissue, the product of cells known as chondrocytes. Although all tissues synthesize the molecules collagen and sulfated proteoglycan (PGS), the types of these molecules synthesized by cartilage are unique to that tissue. Collagen is a main structural protein of skin, tendon, bone, and cartilage. PGS is made up of approximately 10% protein and



90% carbohydrate. Dr. Goetinck explained that, of the two major molecules collagen and PGS, both crucial to normal cartilage development, only the synthesis of PGS is affected in the mutant. He went on to point out that for normal growth you need large quantities of PGS in the embryonic cell matrix. In the embryo, PGS holds water and actually serves to "push" cells apart, a function which is apparently critical in the normal development and growth of cartilage. When asked whether PGS deficiency has been implicated in human dwarfism or other human connective tissue disorders, Dr. Goetinck replied that, so far, it is not known if the synthesis of PGS is affected in any of these anomalies. However, collagen abnormalities are present in a variety of human connective tissue disorders.

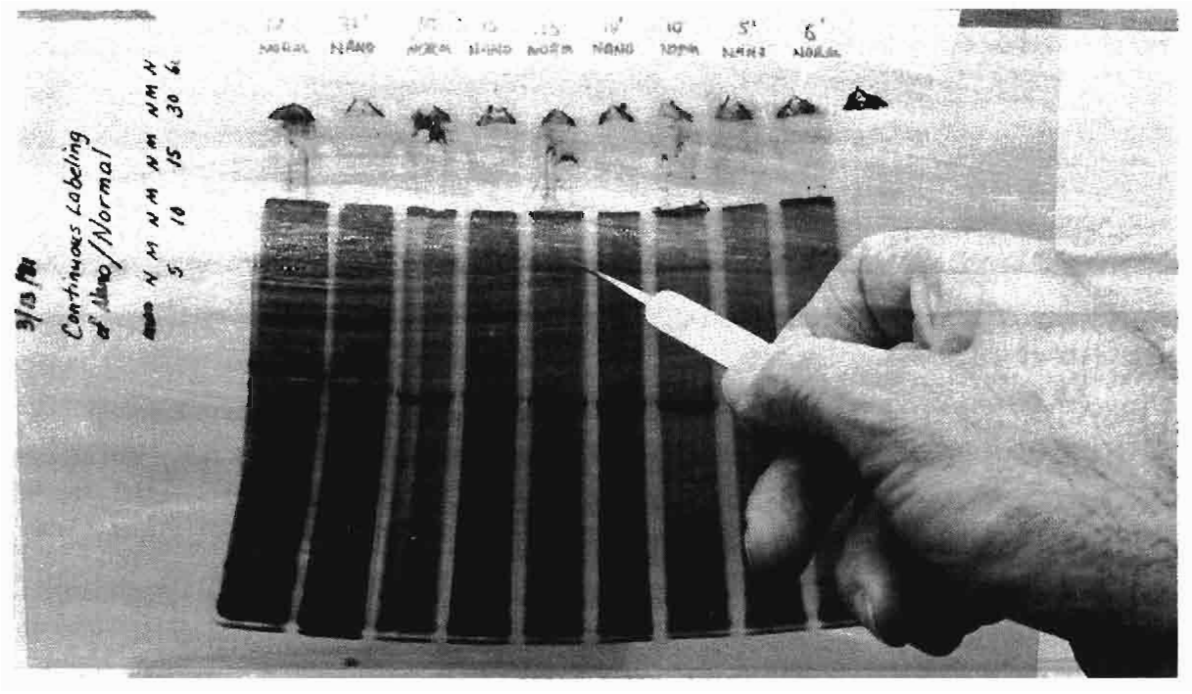


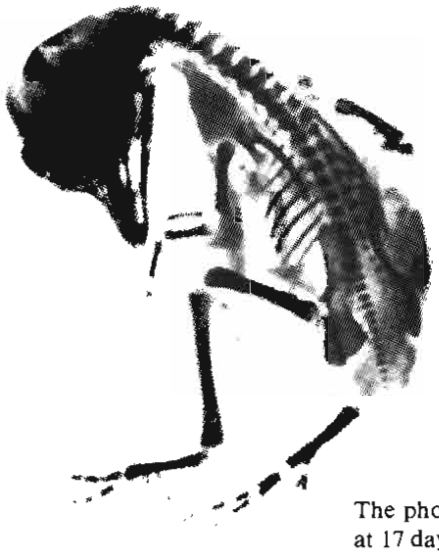
These scanning electron micrographs clearly show the difference in the cartilage of a normal and mutant (nanomelic) embryo. 'A' shows cartilage in a normal embryo. The white bumps are PGS. 'B' shows cartilage in a nanomelic mutant. Note the lack of PGS.

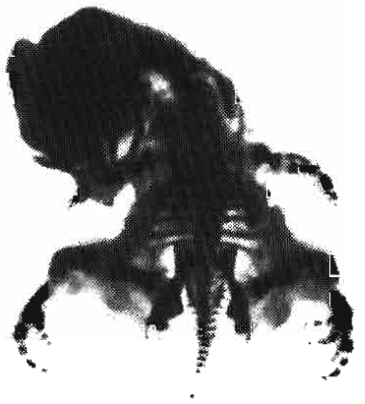
Chondrogenesis, literally the "birth of cartilage," has been analyzed in both types of chick embryo mutants, which Landauer named *micromelia* and *nanomelia,* respectively. Dr. Goetinck noted that *micromelia* is the usual term for shortened limbs. In metric terms, a micrometer is one thousandth of a millimeter. *Nanomelia* was so named because of its *extremely* shortened limbs. A nanometer is a millionth part of a millimeter. Interestingly, the Greek word for dwarf is *nanos,* from which *nano*meter is derived. Dr. Goetinck said he didn't know if the double significance occurred to Landauer when he named *nanomelia,* but imagines that it did.

Dr. Goetinck's studies have centered on the mutant *nanomelia,* which was found to be severely deficient in its ability to synthesize PGS.

Fluorogram showing radiolabelled protein bands. Dr. Goetinck points to the band that is present in the normal chick embryo but absent in the mutant.

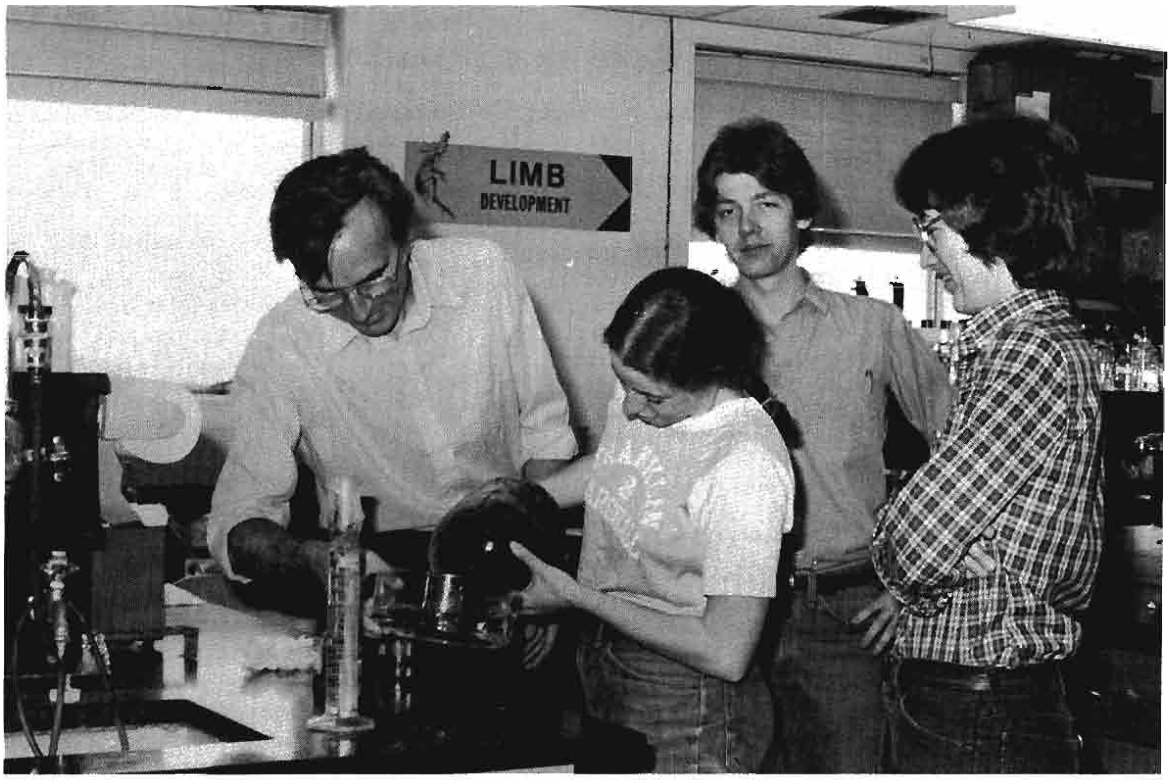






The photograph on the left shows a normal embryo at 17 days (incubation period is 21 days). On the right is a nanomelic embryo at the same stage of development. The failure of cartilage to develop normally in *nanomelia* is apparent in its extremely shortened skeleton.

But where in the developmental process did the problem begin? In the precartilaginous state, or at the stage of cartilage differentiation? These questions needed answering, but as Dr. Goetinck pointed out, they presented difficult methodological problems. For at the very early stages of development, the nor-

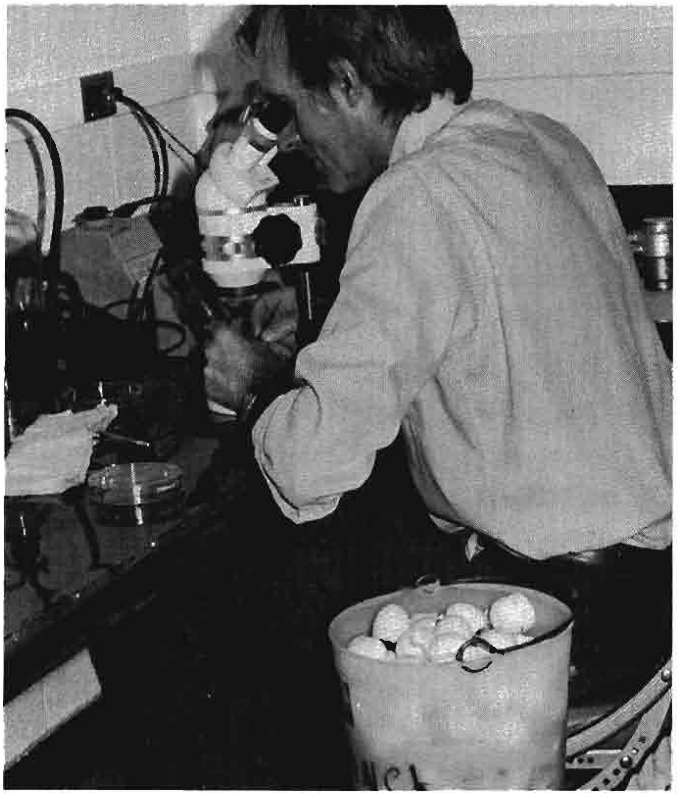


From l. to r. Paul Goetinck with graduate assistants Ann Dannenberg, Scott Argraves, and Peggy Fischer.

mal and mutant cells cannot be distinguished. And since the carrier parents of the mutants will produce only about 25% mutant offspring, some process had to be invented to distinguish between normal and mutant tissue.

Dr. Goetinck and his associates were able to adapt a culture system in which limb bud cells were induced to undergo chondrogenesis. Biochemical and morphological analyses were then conducted on these cultures after 1, 3, and 6 days. It takes 6 days for the cells to develop from an undifferentiated precartilaginous state to the formation of cartilaginous nodules. By the third day the normal cells began to synthesize cartilage-specific PGS, while the nanomelic cells failed to synthesize it. By the sixth day the difference was even more striking. Scanning electron microscopic analysis of the cultures showed no difference after the first and third days. However, at six days a clear difference was evident in the cell matrix. The mutant showed a clear lack of PGS granules.

The answer to the question, When does the failure of the mutant to synthesize PGS begin? was now clear. As Dr. Goetinck summarized it, "In the precartilaginous state the mutant has no effect — it's only expressed in the cartilage."

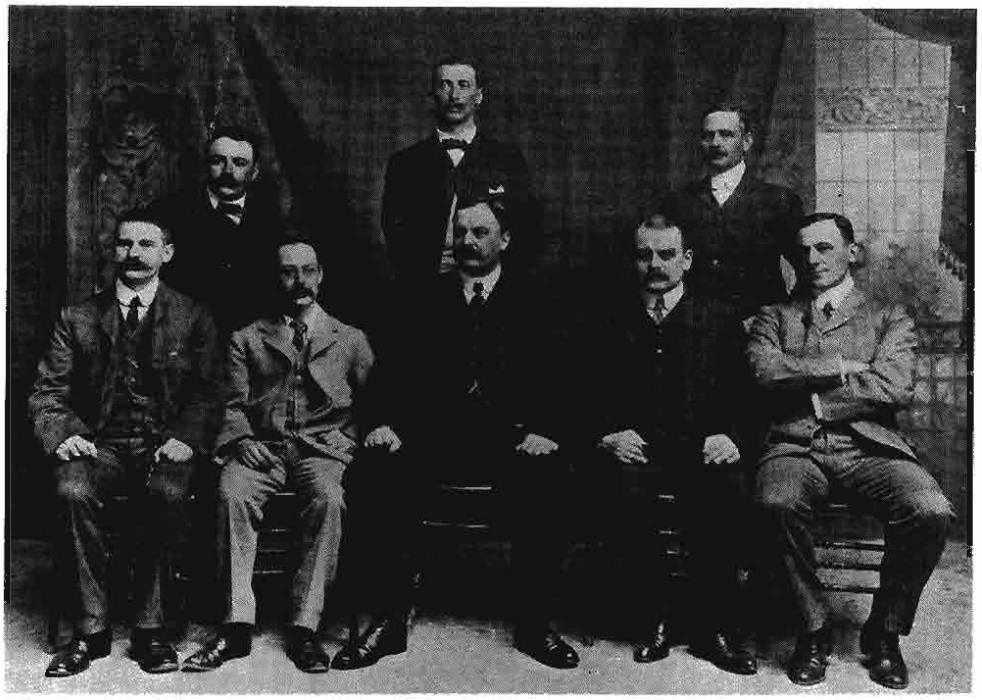


Brucellosis: An Old Story Without an Ending

Sandra Cookson

For many decades, *bovine brucellosis,* or infectious abortion in cattle, has plagued dairymen, veterinarians, and researchers here and abroad. A highly contagious bacterial infection, *bovine brucellosis* causes abortion and decreased milk production. The loss of calves and milk to this resistant disease has proved costly to the dairy industry and to the consumer as well. In addition, it has posed a constant public health danger.

Brucellosis occurs in farm animals other than cattle and is transmitted to humans by contact with contaminated animals or meat and dairy products from contaminated animals. Pasteurization kills the bacteria, as does cooking the meat. Sometimes known as "undulant fever," the disease produces a variety of symptoms in humans including fever, chills, exhaustion, night sweats, and aches and pains. Though a disease of long duration lasting from three to six months, treatment with antibiotics is effective



Mediterranean Fever Commission, 1904
Col. David Bruce, R.A.M.C., seated, center.

The Commonwealth Fund

in humans, but no dependable drug therapy exists for animals.

Happily, *bovine brucellosis* no longer poses a serious threat in Connecticut. Through the efforts of University of Connecticut researchers working at the Storrs Agricultural Experiment Station, and with the cooperation of Connecticut dairymen, the disease has been eradicated in this state. Leander F. Williams, emeritus professor of pathology at the University and leader for many years of an ongoing program of *brucellosis* control in the state, reports that Connecticut's dairy herds had been entirely free of the disease for twelve years, until an outbreak in 1979. The outbreak was confined to a small area of the state, however, and is thought to have been sparked by the illegal importing of untested cows across the state line.

An Ancient Culprit and Its First Modern Detectives

Although the first authenticated case of human *brucellosis* in the United States was not reported until 1905, the disease was known to the ancient Greeks and presumably occurred throughout the Mediterranean area. Hippocrates is credited with having described it over 2,000 years ago in his treatise on epidemics (ca. 450 B.C.). In modern times, British medical officers stationed with garrisons in the Mediterranean between 1751 and 1906 reported a high incidence of "a febrile disease of long duration among troops." The disease was called Mediterranean, Malta, or Rock fever depending on where it occurred.

In 1887 a British medical officer, Col. David Bruce, who was stationed on the island of Malta, isolated certain organisms from several fatal cases of Malta fever among the troops. The organisms, which he described as "micrococi," were eventually named "*brucella*" after their discoverer; and Malta fever was later renamed "undulant fever" because of the undulating temperature curve which is characteristic of it.

The unfortunate soldiers who fell victim to *brucellosis* while serving on Malta contracted it from goats' milk, but this was only discovered in 1906 and largely by accident. It happened when a member of the British government's Mediterranean Fever Commission, while searching for an animal suitable for *brucellosis* research, stumbled on the discovery that the blood of goats agglutinated the Malta fever organism isolated by Bruce.

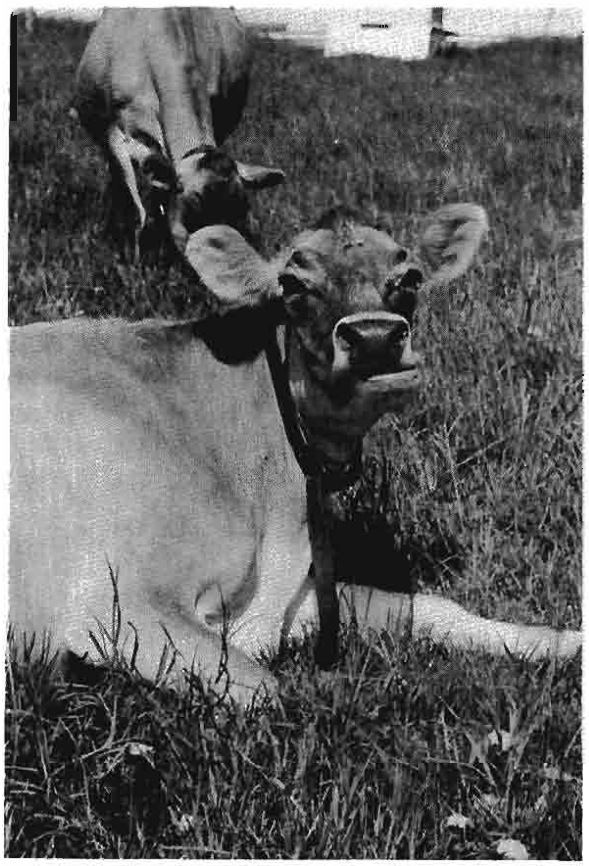
The first link in what was to become a chain of accidental discoveries had been forged a few years earlier in 1897 when Wright and Semple found that blood serum of Malta fever victims agglutinated cells of Bruce's organism. With the new discovery that the blood of apparently healthy goats also agglutinated

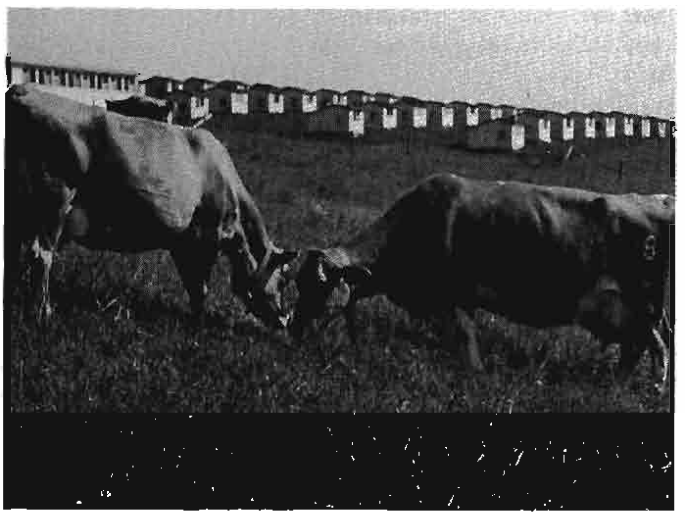
the Malta fever organism, medical officers ordered raw goats' milk banned from the diet of the British troops, and incidence of the disease promptly fell from an average of 355 cases per year to nine cases in 1907.

At about the same time Wright and Semple were observing that the Malta fever victims' blood agglutinated Bruce's organism, a Danish veterinarian, B.L.F. Bang, succeeded in producing both the infection and abortion in cattle. Bang cultured the "bacillus of abortion," as it was generally termed, and then introduced it into the vaginas of pregnant cows. His work was soon repeated in England, Hungary, and Germany.

But it was not until 1914 that the association was made between the "bacillus of abortion" in cattle and Bruce's Malta fever organism. In that year an English bacteriologist found that a high percentage of cows supplying milk to the city of London had agglutinins in their blood and milk for the organism isolated by Bruce. Meanwhile another accidental discovery was made by Alice Evans at the USDA, which established the close relation of Bruce's Malta fever organism to the bacterium that Bang had shown to cause infection and abortion in cattle. While trying to identify some milk cultures, Evans noticed a striking similarity between texrbook descriptions of Bruce's organism and Bang's "bacillus of abortion."

A few years earlier, in 1910, two investigators at the Illinois Experiment Station were the first in the United States to isolate *brucella abortus* from aborting cows. Isolation of the organism from cows' milk was accomplished a year later by workers at the U.S. Bureau of Animal Industry who were actually trying to find the tuberculous organism in the milk of apparently healthy cows, using the guinea pig inoculation method. Another accidental discovery, this one





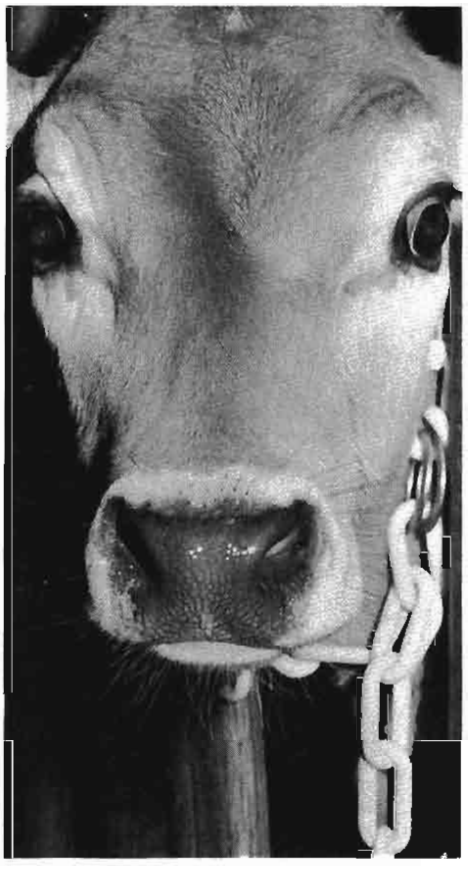
proved to be of considerable importance, for it showed that milk is indeed the source of human infection; and that apparently healthy cows which no longer abort can continue to shed *brucella* organisms for years.

Brucellosis Research and Control

With the benefit of these early diseoveries, seientists began work to develop a test for efficient and accurate diagnosis of the disease in cattle. They tried many different serologic tests on blood and milk. They performed tests for allergic response, and did bacteriological analyses of milk and aborted material. For many years the blood serum tube agglutination test has been generally recognized as the simplest and most accurate method for diagnosing *brucellosis* in cattle. It is based on the ability of the blood of infected persons and animals to agglutinate suspensions of the causative bacterium. This is the phenomenon which Col. Bruce observed in the blood of his Malta fever cases.

By 1914 investigators at the Storrs Experiment Station were involved in the development of testing methods, while at the same time, they were devising ways to control the spread of the disease in Connecticut's dairy herds. In early work at Storrs, done by Rettger and White in 1918, both the tube agglutination test and the complement fixation test were used. The complement fixation test was discontinued in 1930, however, and the tube agglutination test is still the most widely used at the Storrs *Brucellosis* testing laboratory, where in 1980, 24,578 of these blood tests were performed.

By 1926 the Storrs scientists had succeeded in eradicating *brucellosis* from the University's dairy herd through blood tests and immediate segregation

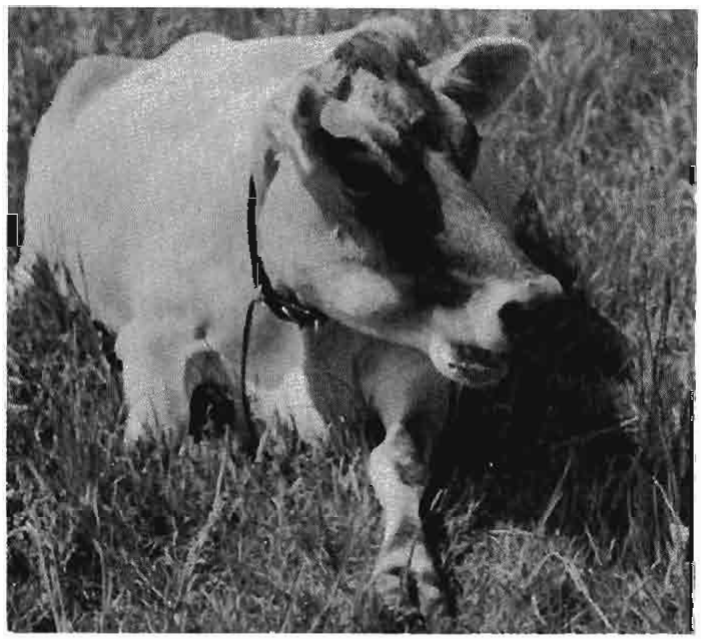


and destruction of infected animals and those identified as positive reactors.

Connecticut and Pennsylvania were the first states to start *brucellosis* control programs in this country. A cooperative program between the Storrs Experiment Station and the Department on Domestic Animals (now the State Department of Agriculture) was established in 1931, in which blood testing was done at the Storrs laboratory and infected cows were ordered quarantined at the owner's expense. A joint state and federal plan was adopted a few years later which allowed the sale of infected cows for immediate slaughter or into herds not under supervision, but whose milk was pasteurized.

Connecticut was the first state to require calf vaccination, and in 1941 tests and vaccinations were made available at state expense. In 1945 vaccination of calves between four and eight months of age was made mandatory, and by 1953 the regulation was changed to require the vaccination of all female calves. A 1954 report by Storrs Experiment Station researchers stated that the control programs developed as a result of research conducted at the Storrs Experiment Station had reduced the incidence of *bovine brucellosis* in Connecticut by about 80% (from 20% to less than 5%). The report estimated savings to Connecticut dairymen as a result of the state control program at more than one million dollars annually.

Connecticut's record of *brucellosis* control, in which Storrs Experiment Station scientists have played a major role, is proof that constant vigilance is still needed to keep the state's dairy herds free of this dangerous and costly disease.



PROJECTS

PROJECT NO.	TITLE	PROJECT LEADER(S)
AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY		
216	Population Trends in Connecticut	T.E. Steahr, W.H. Groff, K.P. Hadden
470	Outdoor Recreation and Public Interest: Benefits and Cost in Federal and State Resource Planning (W-133)	M.W. Kottke
497	A Forest Management, Marketing and Small Industry Development Pilot Program	W.R. Bentley
500	An Econometric Submodel for New England Agriculture	T.C. Lee, S.K. Seaver, R.O.P. Farrish
501	Socio-Economic Factors and Rural Land Use (NE-125)	R.L. Leonard, I.F. Fellows
502	An Analysis of the Spatial Organization of the Northeast Dairy Industry (NE-126)	D.G. Stitts
505	Impact of In and Out Migration and Population Redistribution in the Northeast (NE-119)	T.E.Steahr
516	Economic Impacts of the 200-Mile Limit on Rural Northeast Coastal Communities (NE-128)	M.A. Altobello, R.O.P. Farrish
523	Improving the Distribution of Soeio-Eeonomic Resources in Rural Areas (NE-129)	K.P. Hadden
532	An Economic Analysis of Contract Production and Marketing of Broilers and Eggs in the Northeast (NE-134)	D.G. Stitts
534	Socio-economic Perspectives of Small Farmers	W.H. Groff
538	Impacts of Tourism on Rural Economic Development (NE-137)	M.W. Kottke
AGRICULTURAL ENGINEERING		
504	Bio-Physical Factors Affecting Energy Requirements for Poultry Production (NE-127)	R.P. Prince, P.E. Stake
506	Systems Design for Controlled Environment Plant Growth (NE-136)	J.W. Bartok, R.A. Aldrich, R.A. Ashley

ANIMAL GENETICS

436	Genetic Control of Cadmium Susceptibility	L.J. Pierro
457	Stress Response Compounds in Adverse Biological Activity and Improved Resistance in Potatoes (NE-94)	N.W. Klein, L.J. Pierro
522	Serum Proteins in Development and Embryo Culture in the Surveillance for Congenital Abnormalities	N.W. Klein
524	Genetic Control of Connective Tissue Metabolism	P.F. Goetinck

ANIMAL INDUSTRIES

143	More Efficient Methods of Producing Beef in the Northeast	W.A. Cowan, N.S. Hale
144	Endocrine Relationships in the Reproductive Performance of Sheep	W.A. Cowan, C.O. Woody, Jr.
456	Control of Reproduction in the Bovine Female (NE-72)	C.W. Woody, Jr., W.A. Cowan
458	Development of Puberty in Males and Control of Spermatogenesis	C.O. Woody, Jr., J.W. Riesen

HOME ECONOMICS AND FAMILY STUDIES

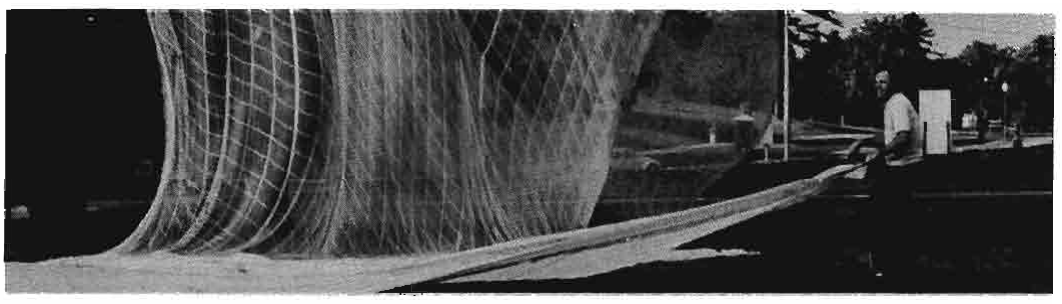
485	An Interstate Urban/Rural Comparison of Families' Time Use (NE-113)	E. McCabe

MICROCHEMISTRY LABORATORY

489	Analysis of Xenobiotic Residues in Connecticut Honey and Cider	D.W. Hill

NATURAL RESOURCES CONSERVATION

490	Projecting Local Economic Impacts of Forestry Activities	J.E. Bethune, W.R. Bentley
525	Wood Removal Impacts on Small Private Non-industrial Forests	J.E. Bethune, D.R. Miller, W.R. Bentley



529	Forest Microclimate and Water Use Characteristics	D.R. Miller
533	The Dynamics and Energetics of the Soil-Plant-Atmosphere Continuum (NE-48)	D.R. Miller

NORTHEASTERN RESEARCH CENTER FOR WILDLIFE DISEASES

511	Studies of Wildlife Diseases	S.W. Nielsen, D.S. Wyand

NUTRITIONAL SCIENCES

346	Mode of Inheritance and Gene Actions of Poultry Mutations	R.G. Somes, Jr.
455	Improving the Assurance of Quality and Safety of Consumers' Food (NE-83)	P.E. Stake
496	Concentrations of Prostaglandins, Serum Triglyceride, Cholesterol and Fatty Acid Profile of Patients with Chronic Renal Insufficiency	E.J. McCosh-Lilie
499	Genetic-Physiological Mechanisms Associated with Nutrient Utilization in Poultry (S-133)	R.G. Somes, Jr.
508	Human Nutrition Improvement (NE-73)	R.G. Jensen, A.M. Ferris
520	Lipid Content of Milk from Mothers of Full- and Pre-Term Infants	R.M. Clark, A.M. Ferris
531	Vitamin A-Nutriture and Nuclear Binding of 14C and 3H-Labeled Retinoids in Rat Testes	K.L. Knox
535	The Role of Insulin in Renal Calcium Reabsorption	L.H. Allen
536	Influence of Excess Vitamin E and Other Compounds on the Absorption of the Fat-Soluble Vitamins	W.J. Pudelkiewicz

PATHOBIOLOGY

115	Brucellosis	L.J. Pierro
117	Control of Infectious Mastitis in Dairy Cattle	L.J. Pierro
118	Survey of Animal Diseases Occurring in Connecticut	E.S. Bryant, D.S. Wyand, L. van der Heide
122	Pullorum Disease Control	L.J. Pierro
412	Infectious Diseases Affecting Reproduction in Dairy Cattle (NE-71)	M.E. Tourtellotte
481	Detection and Control of Three Economically Important Avian Diseases (NE-109)	L. van der Heide
487	Resistance to Mastitis in Dairy Cattle (NE-112)	T.J. Yang
514	Studies on Gastroenteric Diseases of Dogs and Other Animals	H.J. Van Kruiningen
515	Enteric Diseases in Adult Cattle	H.J. Van Kruiningen
517	Avian Adenoviruses: Factors Affecting Isolate Identification	C.N. Burke, L. van der Heide

518	Mycoplasmosis in Calves	M.E. Tourtellotte, S.W. Nielsen
526	Hematological Disorders	T.N. Fredrickson
527	Cells Involved in Spontaneous Regression of Tumors	T.J. Yang

PLANT SCIENCE

162	The Use of Herbicides in Forage Crop Management	R.A. Peters, W.M. Dest
459	Weed-Crop Competition (NE-92)	R.A. Peters
476	Selection and Propagation of New and Unique Forms of Native Conifers from Witches'-Broom Progeny	S. Waxman
479	Breeding Cool Season Forage Species for Improved Feeding Value and Produetivity (NE-106)	W.W. Wasnko
480	Breeding and Evaluation of New Potato Clones and Varieties in the Northeast Area (NE-107)	R.A. Ashley
492	Forage-Livestock Systems for Land with Soil and Site Limitations (NE-114)	D.W. Allinson, R.A. Peters
494	The Cytogeneties, Hybridization Behavior, and Horticultural Improvement of *Vinca*	R.D. Parker
507	Origin, Transformation and Management of Nitrogen in Soils, Waters, and Plants (NE-39)	G.F. Griffin
519	Pesticide Impact Assessment Program	M.G. Savos, R.G. Adams, R.A. Peters
521	An Integrated Program for Environmental Planning	W.C. Kennard, M.W. Lefor
537	Characterization of Seleeted Connecticut Soils Formed on Glacial Tills	H.D. Luce
539	Impact of Climatic Variability on Agrieulture (NE-135)	W.C. Kennard