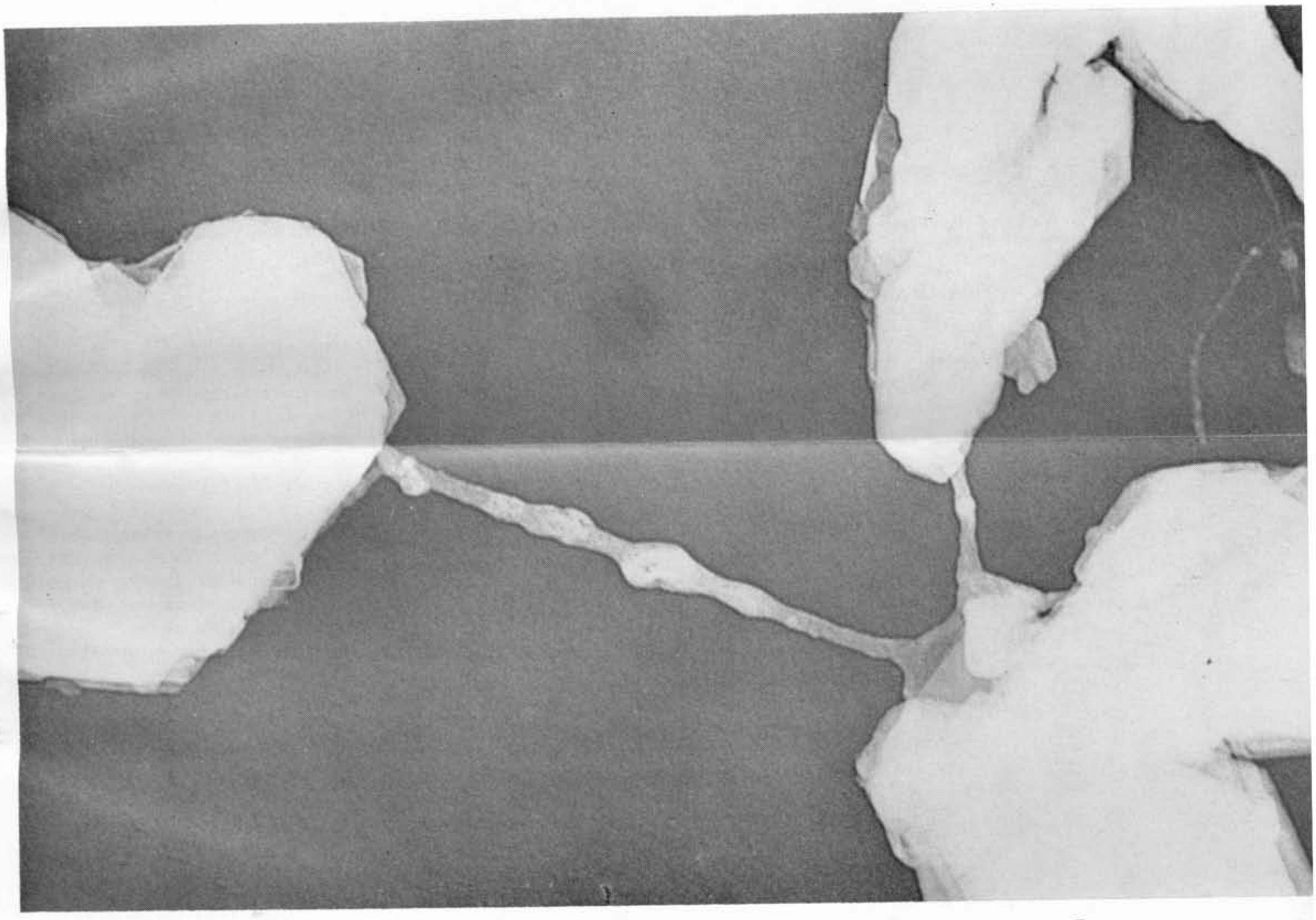
Frontiers of PLANT SCIENCE

FALL ISSUE

1963



Close-up of clay: an electron micrograph of freeze-dried kaolinite . . . see page 5

THE CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN

FROM STUDIES IN GENETICS

New Ways To Make New Plants

Bruce B. Miner

One of our Connecticut neighbors, John C. Devlin, who writes for the *New York Times,* visited the Station a few weeks ago. He came to talk to Richard A. Jaynes,* the geneticist in charge of research on chestnuts, and to see nine new hybrid varieties that seem to warrant more extensive trials.

Mr. Devlin wrote a story for the *Times,* and we received a large number of inquiries immediately thereafter—as we did when free-lance writers J. C. Furnas and Alma C. Moore visited us and wrote stories on Connecticut Station chestnuts.

Why all this interest in chestnuts? Nostalgia accounts for some of the letters from throughout the United States and Canada. People fondly remember the great trees of their youth. Other letter writers have discovered sturdy young trees they think may be resistant to the blight that wiped out the chestnut as a dominant tree in Connecticut woodlands. Still other inquirers are nurserymen or nut growers who seek productive new trees, or amateurs who like to grow nuts.

The feature stories by Mr. Devlin, Mr. Furnas, Mrs. Moore, and others tell a story of scientific achievement.

Another way to report progress in plant science research is through Station Bulletins. Some of these, addressed to scientists, are written in their technical language. Others—and we hope that our Bulletin 657 on hybrid chestnuts is among them—are written to be useful to those with either amateur or professional interest in the subject reported.

So in various ways the Station again provides useful, practical information for those who can use the new knowledge scientists have discovered. The Station can do this with assurance because the plant breeding represented by the new hybrid chestnuts is based on a sound foundation of research in genetics, the science of heredity.

The nine new hybrid chestnut varieties are a dividend on an investment in research made many years ago. It is a little like what can happen to money—this business of investing in research.

Put $100 into a safety deposit box and take it out 20 years later and it is still $100, no more and no less. Put $100 into a savings account or some investment where the value it represents can be used, and with reasonably good fortune you expect to have considerably more than $100 after 20 years.

Put new knowledge of genetics—new knowledge that costs dollars and brainpower—in a scientific journal. So far, it is simply a deposit in the bank of knowledge. To transmute this research into practical value, somebody must do something with it. The value may lie in clarification of a detail of inheritance, so that the discoverer or another scientist can take one more step toward understanding ancient mysteries of plant growth. Or the journal paper itself may suggest new ways to develop better varieties, new ways to modify the processes of heredity.

The return on an investment in genetics research may be phenomenal. Professor Zvi Griliches, University of Chicago economist, calculates an approximate annual return of $7 in perpetuity, as of 1955, for every dollar that has been invested in research on hybrid corn. That is 700 per cent, every year.

Geneticists at this Station have a long record of making discoveries, great and small, putting them into the scientific record, and then doing something, so that dividends become almost inevitable.

More often than not, the small company of Connecticut Station scientists concerned with studies of heredity have come close to fitting a definition of genius set forth by the philosopher William James in 1879, when the science of genetics was unknown.

Nine new hybrid chestnuts are described in Bulletin 657. None has all of the good qualities of the American chestnut, nor is any one of them likely to replace it in Connecticut woodlands. All are resistant to the chestnut blight, all are crosses between the American chestnut and one or more Oriental species. The crosses were made 20 or more years ago.

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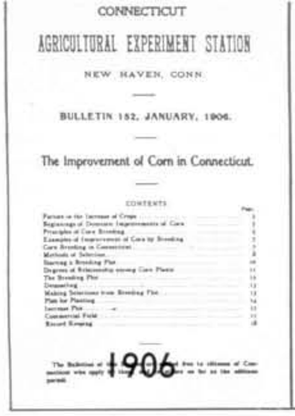
* Dr. Jaynes took over the chestnut investigation at this Station after working for several years with Arthur H. Graves, Station consultant in genetics. Dr. Graves died last December.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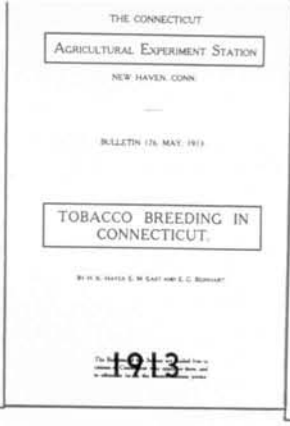
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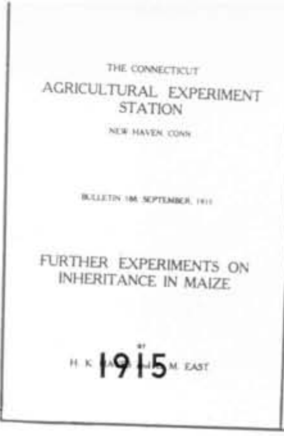
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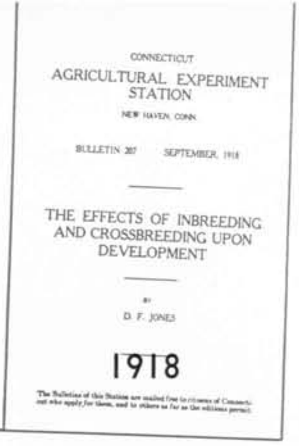
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THE EFFECTS OF INBREEDING AND CROSSBREEDING UPON DEVELOPMENT
BY
D. F. JONES
1918
The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

"The man of genius," James wrote, "is he who will always stick-in his bill, as it were, at the right point, and bring it out with the right element—'reason' if the emergency be theoretical, 'means' if it be practical—transfixed upon it."

Three men handled genetics research at this Station from 1905 to 1960: Edward M. East from 1905 to 1909, H. K. Hayes from 1909 to 1914, and Donald F. Jones from 1914 to his retirement in 1960. With surprising regularity these men and their co-workers came up with both reasoning and means that proved to be of great value.

Because Jones was in charge of research in genetics for nearly a half century, it is appropriate to cite from his career a classic example of the genius William James described 11 years before Jones was born. Jones came into the hybrid corn story at a critical point. Hybrid vigor in corn was known but unexplained in theory and impractical in application. Jones advanced a theoretical explanation that was and is workable, and he found a practical means to put hybrid vigor to work in American corn fields. With his four-way cross he helped to make possible the 700 per cent annual return on the hybrid corn research investment.

Perhaps even more important, Jones in his own career exemplified a kind of leadership he spoke of in 1935 when he lectured in Michigan on plant breeding. "The real value of a scientist," he said, "is measured not alone by what he does himself, but by what he makes possible for others to accomplish."

Jones made it possible for plant breeders everywhere to tailor-make hybrid corn for specific conditions and needs. He invented a way to make inventions. More than this, he inspired and directed the early research of the young geneticists who worked with him, as his predecessor Hayes had helped him, and as Hayes' predecessor East had worked with Hayes.

Indeed, from his professorial chair at Harvard, East was an official or unofficial consultant to Connecticut Station geneticists for nearly 30 years.

H. K. Hayes was a native of Granby. He was first employed by the U.S. Department of Agriculture to conduct tobacco investigations in the Connecticut Valley. In that capacity he worked with East at the Station, and in 1909 Hayes took charge of plant breeding research here when East left to go to Harvard.

Hayes continued the studies of inheritance in corn until 1914. A few months later he began a distinguished career in research and teaching at the University of Minnesota. He retired in 1952.

Hybrid Corn Goes to Market

Edward M. East, in four years at this Station, carried on intensive studies of tobacco, potatoes, and corn. In 1911 he published with H. K. Hayes a classic in the early literature of genetics—Connecticut Station Bulletin 167, "Inheritance in Maize." At about the time of World War I, East's interests turned increasingly to problems of eugenics. One of the young men he invited to a round table on population problems in 1925 was Henry A. Wallace. Donald Jones said that this marked the first appearance of Mr. Wallace in national affairs. Be that as it may, we can be sure that Mr. Wallace was thinking about corn as the conferees discussed population trends. The following year, 1926, Mr. Wallace organized the first company to develop, produce, and sell hybrid seed corn. He took to market the scholarship of Darwin, Mendel, Shull, East, Hayes, Jones, and their contemporaries.

In these days of bigness, it is customary to speak of East and Hayes and Jones as chiefs of a Department at this Station. They were chiefs, of that there is no doubt. But the Station Department of Genetics has always been small. East *was* the department in his day, Hayes had only a part-time helper as did Jones until 1921 when Paul C. Mangelsdorf, a graduate student, became his assistant. Other graduate fellows have come and gone, but the full-time scientific staff in genetics has seldom been more than four or five men. Presently there are three.

One of the three, Seaward A. Sand, has been concerned principally with studies of Nicotiana. He has shown how to transfer genes for bluemold resistance and wildfire resistance into shade tobacco. Dr. Sand recently returned from sabbatical leave, studying and lecturing at the University of Dublin.

Dr. Carl D. Clayberg has found ways to put desirable characteristics from wild tomatoes into commercially useful varieties. He is also widely known for his work with the gloxinia group of ornamental plants.

Dr. Jaynes, whose work with chestnuts began this story of research in genetics, is also beginning a study of the Kalmia and Rhododendron groups. When the details of inheritance in these plants are better understood, it may be possible to create many variations of these valuable ornamentals.

Science, it has been said, offers a means whereby ordinary men can do extraordinary things. Extraordinary men can do even better. East, Hayes, Jones and those who studied under them have written exciting chapters in the story of genetics. The young geneticists at the Station face new times with new knowledge. What they will accomplish no one can predict. We trust that now and then their work will continue to warrant stories in the *Times* and other papers, stories of science put to work for the people of Connecticut.

Dr. Clayberg has successfully transferred chromosomes from wild species of tomatoes to improve cultivated varieties. The wire cage over the plant prevents pollination by bees.

The face fly annoys cattle.

FIGHTING THE FACE FLY

Biological Control Is Far From Simple

Raimon L. Beard

FOR SOME 3500 YEARS *Bombyx mori* has been cultivated for its silken threads. This, the silkworm, has been so thoroughly domesticated that nowhere does it exist in the wild state. Like a highly bred milch cow that could not long survive on the open range, the silkworm needs tender loving care. It requires proper food and lodging and protection from disease.

A kind of "domestication" of insects is required for experimental, and sometimes applied, efforts to reduce damage caused by pest insects that destroy our crops and possessions, transmit disease, or annoy us.

Most laboratory experimentation on insects is made possible by routine rearing of test insects. Cockroaches, flies, mosquitoes, beetles, and a great variety of other insects are widely raised in large numbers. Their nutritional diets and environmental likes and dislikes have been established, so their care is easy. Domesticated to the laboratory, their physiology, reproductive potentials, responses to chemicals, reactions to environmental factors and competition, and their behavior can be studied.

Not so easy to raise in the laboratory are many other insects, so fastidious that they resist repeated attempts to culture them. Some mosquitoes are easy to raise; others seem impossible. No one has successfully established a culture of tsetse flies, and public health programs are hindered by not having these and other disease vectors available for experimentation at all times. Inability to rear the appropriate test insect can be a serious bottle-neck in entomological research.

Insect rearing can be an art, a science, and a technology. Resembling the "green thumb" of the gardener, the artfulness of the entomologist is expressed in the inventive designing of cages and environments and the catering to the whims of temperamental creatures. If the insect thrives at all in the laboratory, scientific comparisons and experiments can lead to improved cultures. Technology becomes essential when mass rearing demands the most efficient production.

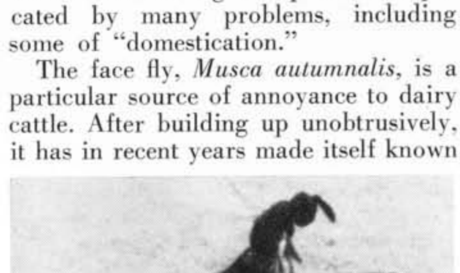
RAISED 100 MILLION FLIES

In no areas are the art, science, and technology of insect rearing more important than in biological control. Illustrating a special type of biological control, the eradication of the screwworm in the southeastern United States by the release of sterile-male screwworm flies is now well known. It has demonstrated the effectiveness of a novel idea carried to a practical conclusion. Essential to the program was the mass production of flies. Rather difficult to visualize, 100,000,000 flies were produced each week. This becomes more graphic if it is realized that 105,000 pounds of meat and 4000 gallons of blood and a staff of 185 men were required to produce this number.

Biological control of insects by their parasitic and predatory antagonists may also call for a large-scale culture program. Here, however, the problem is doubled, for both the parasite and its host must be cultured. The host may be the target pest insect. More often the host is a substitute, equally acceptable to the parasite, but one much easier to culture than the pest itself. Sometimes a parasite can be fooled into attacking something quite different from its normal hosts.

In our laboratories we are investigating four parasites that attack the face fly. Their use as a quick and easy method of controlling this pest is complicated by many problems, including some of "domestication."

The face fly, *Musca autumnalis*, is a particular source of annoyance to dairy cattle. After building up unobtrusively, it has in recent years made itself known in large numbers over most of the United States. Since 1960, when it was first observed extensively in Connecticut, Mr. W. T. Brigham of this Department has made field surveys and trials in its control. His collections yielded three parasitic insects — two wasps and one beetle — all of which justified study as possible control agents.



Biological control: Nasonia vitripennis, a wasp, parasitizes a house fly pupa.

The face fly itself can be reared in the laboratory only with the greatest difficulty and in small numbers. Fortunately, an alternate host for these three parasites, a flesh fly, can be reared easily. This was not always so. Early this summer, for a period of about six weeks, the flesh flies were repeatedly brought from the field and exposed to a variety of situations and types of food. The flies would survive a short time and then die without producing offspring. They could not be tempted to reproduce. All at once reproduction began, and thereafter it mattered little which of several kinds of food was offered. The culture has since been continued with no difficulty. The sudden success probably resulted when, out of a sizeable number of "wild" flies a certain few happened to be satisfied with laboratory conditions. This selection and subsequent breeding has developed a laboratory strain that may be quite different genetically from the field population.

NASONIA FAILS IN THE FIELD

One fly parasite, *Nasonia vitripennis*, is extremely easy to rear in the laboratory. Last summer, a few hundred thousand were cultured and released in a small, isolated cow pasture, aimed at controlling the face fly. To evaluate the results, laboratory reared face fly pupae were placed in the field as bait traps, and naturally occurring fly pupae were collected. Not a single pupa was found to be parasitized by *Nasonia*. It was suspected that the parasite was so "domesticated" to the laboratory that it could not be effective in the field. On the other hand, the three parasites thriving in nature have so far resisted attempts to culture them in the laboratory. One of these has been successfully reared, on a still different host, in a Canadian laboratory. But even this strain, imported, has yet to become adapted to our host and conditions.

By evolutionary selection, insects become best fit to live in a particular environment. Thus when the environment changes, as from field to laboratory, or from laboratory to the field, an evolutionary adaptation may be required. This is not to say that these types of selection and adaptation block biological control which requires mass rearing of insects. It does mean that there are genetically controlled processes that need to be considered in any such study and program.

GIANT MOLECULES IN AND ON CLAYS

The Cover Photo, a micrograph made at Washington State University, was first published in Soil Science of America Proceedings as part of a technical paper with Dr. Stephen L. Rawlins of this Station as senior author. A soil conditioner appears as strands bonding the clay aggregates.

Charles R. Frink

CLAYS ARE AMONG the most versatile of the common things around us. Paints, paper, rubber, adhesives, greases, plastics, cement, ink—these are some of the many products in which clays are used. Clays are also employed in a variety of industrial processes such as water clarification, disposal of radioactive wastes, and oil well drilling. We are interested in clays because of their relation to plant growth.

This seemingly bewildering variety of uses rests on a few basic properties of clays. Among the most important of these properties is the astonishingly large surface area of clay particles. Individual clay particles are far too small to see with the naked eye, less than 0.002 millimeters in diameter, but in mass their surface area is immense. For example, the total surface area of 1 oz. of clay may be about five and one-half acres.

The second most important property of clay is its rather unique, planar structure. A familiar example of this structure is found in the micas, whose crystals can be easily separated to give paper thin sheets. Clays have essentially this same structure but are microscopic in size. Each sheet or layer is composed of aluminum and silicon atoms, linked together by oxygen atoms in a three dimensional array to produce a crystal structure commonly known as a layer silicate.

THE CLAY "SANDWICH"

The third essential feature of clays, which is related to their small size, large surface area, and planar structure, is their ability to adsorb, or hold in contact, a wide variety of substances both between their sheets to form a sandwich, and on their external surfaces. This is analogous to buttering the sides of the sandwich. Adsorption between the sheets or leaflets causes swelling of the clay, but this swelling is limited by attractive forces between the sheets with the result that the spacing of the sandwich is limited to a distance of about 10 to 20 Å (Angstrom units). Since this distance is approximately the same as the size of most chemical compounds, and since the swelling of clays can be controlled by various means, clays can act as sieves or traps for some chemicals. Adsorption of substances on the sides of the sandwich does not cause swelling, but it does frequently change other properties of the clay, such as the ease with which it may be wet with water.

CLAYS HOLD PLANT FOOD

Most of the uses to which clay is put depend in large part on the kind of chemical which is contained between the layers. For example, soil clays hold most of the nutrients required by plants and prevent them from being leached from the soil by rainfall. Occasionally this ability is detrimental to plant growth: potash can be held so tightly by soil clays that it is unavailable to plants. Clays used in paints are often coated with some organic chemical to improve their wettability in the liquid vehicle. Many other possibilities exist for modifying the properties of the clay, but it has recently been found that the effect is mutual: clays may also modify the properties of compounds adsorbed in or on them.

The compounds we have studied have been organic monomers with relatively small molecules. They are the building blocks with which the organic chemist can construct the myriad of polymers familiar to us as the synthetic plastics, fabrics, rubbers, and other items which are so much a part of our present economy. All of these giant molecules, or polymers, are made from the simple monomers joined end-to-end in various configurations. Usually it is necessary to provide an additional agent or catalyst and heat the compounds, perhaps under pressure, in order to cause these reactions to occur. We have found, however, that if certain monomers are adsorbed in or on clays, they polymerize spontaneously, and occasionally produce polymers differing from those formed in the absence of clay.

Working in collaboration with Dr. Henry Friedlander,* we treated clays with various gaseous hydrocarbons, and found that several of them polymerized spontaneously, forming on the clay a coating which resembles the chemical structure of rubber. The clays no longer were readily wet by water, and their capacity to adsorb other materials was reduced somewhat. While this was exciting, only small amounts of polymer were formed and the reactions were difficult to study. Surprisingly, the polymer formation took place only on the edges of the clay sheets.

We looked for compounds which could be inserted between the clay sheets, reasoning that much larger amounts could thus be adsorbed by the clay. Two such compounds were found, vinyl pyridine and acrylamide, both important in the study of vinyl polymers. These compounds were adsorbed between the sheets of the clay and large amounts of polymer were formed. We studied the polymerization of vinyl pyridine most extensively, and found that the clay contained up to 10 per cent of polymer in some experiments. Moreover, measurements of the extent of swelling by X-ray diffraction indicated that the clay sheets were fixed at a distance of about 14.8 Å apart. Since the clay sheet itself is about 9.5 Å thick, this leaves a space of about 5.3 Å for the organic polymer.

POLYMER TILTED BETWEEN CLAY SHEETS

Knowing the length of the polymer molecule, we also know that it is not standing on end, but is lying with its backbone of carbon atoms generally parallel to the clay surface. We were able to deduce further that the polymer must be slightly tilted, or perhaps attached in some way to irregularities known to occur on the surfaces of the clay sheets, since the polyvinyl pyridine molecule is slightly thicker than the space of 5.3 Å available for it. We also found that polymerization of vinyl pyridine in the interlayer space had reduced the capacity of the clay to adsorb other substances by about 50 per cent. Since our calculations showed that 10 per cent polymer would cover about 50 per cent of the surface of the clay, we were quite pleased with these results.

We studied one other compound, styrene, which is a building block for polystyrene, one of the first compounds to be studied by polymer chemists. This compound appeared to be intermediate in its method of reaction, forming partly on the outside and partly between the leaflets or sheets of the clay. Swelling properties of the clay were reduced slightly, it wet poorly, and had a slightly reduced sorptive capacity.

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* Research and Development Division, American Machine and Foundry Co., Springdale, Connecticut.

The mechanism by which these polymerization reactions occur is not yet understood. As mentioned earlier, heat, pressure and a catalyst are usually required for such reactions. The clay, or something in the clay, is apparently capable of acting as a catalyst at room temperature and pressure. In searching for this catalyst, we found that most clays, even those from pure clay deposits such as the ones we used, contain small amounts of organic free radicals. These free radicals are extremely reactive, short-lived fragments of organic compounds which are known to initiate or catalyse many reactions, including those of polymerization. We also found that treating the clay to remove the source of the free radicals prevented some, but not all, of the polymerization reactions from occurring.

Clays, which play such an important role in soil fertility and plant growth, subjects which this Station has studied for many years, are also important in a wide variety of industrial applications. Furthermore, we may now have found a potential new use for clays, namely that of controlling and tailoring the production of organic polymers, which alone or combined with clays have innumerable applications.

Biological Control in 1890

The study of biological control of insects goes back many years. In the 1890 Report of this Station, mycologist Roland Thaxter reported a destructive epidemic among tomato worms. The parasitic fungus was a species of *Empusa*. Late in the summer of 1890, Thaxter also observed that great numbers of grape leafhoppers in a Meriden vineyard were entirely destroyed by another species of *Empusa*, and a cabbageworm was found infected with apparently the same fungus.

"The matter was of some economic interest," Thaxter wrote, "from the fact that the *Empusa* in question is destructive to numerous noxious insects and would be perhaps the most available species to employ should it be found practicable to use such fungi as a means of artificially spreading disease among injurious insects."

Thaxter immediately conducted an experiment in which he showed that the *Empusa* did in fact kill cabbage worms.

Fungi, bacteria, viruses, predators, and parasites help to regulate insect populations. To appreciate some of the difficulties that arise in manipulating these biological controls—in this instance parasites—see the article by R. L. Beard on page 4.

Organic Matter Production In Forests

Study Shows Efficiency Of Red Pine Stand

George R. Stephens, Jr.

INDUSTRY NOWADAYS emphasizes production and efficiency. Those in agriculture are equally concerned. Production of any kind requires utilization of an energy source; for plants the primary energy source is sunlight. Therefore, we are vitally concerned with the ability of plants to utilize solar energy in the production of organic matter.

Much is already known about the productivity of cultivated crops. But what of our wild crops such as forests? How do we compare such diverse crops as sunflower and corn to dogwood and pine or such units as bushels to board feet? Obviously we need a common denominator, and in this instance we can use the dry weight of material produced per unit of land area. Standards of utilization vary among crops, however, and we usually harvest only a fraction of the total production. Thus a valid comparison must include the total production of organic matter.

Organic matter, whether it be food or fuel, represents a stored form of energy. Over the course of a year we receive a tremendous input of solar energy. However, common sense tells us that plants in our climate cannot utilize all of this energy because they are dormant or will not grow during much of the year. During the growing season, say May through September, we receive about 2.755 million million (2.755 x 10^{12}) calories of solar energy per acre. Only a small portion, 5 per cent or less, is actually used in photosynthesis for the formation of new organic matter. Part of this captured energy is lost as heat in chemical reactions occurring within the plant during respiration. The balance remains stored as organic matter in the plant. But how is this stored energy distributed in a forest?

To answer this question we looked for the simplest condition—a dense, uniform stand composed of a single species.

We selected a 27-year-old red pine plantation in northeastern Connecticut as our starting point. We assumed that the crown canopy was intercepting nearly all of the incoming radiation, and this was verified by the lack of understory vegetation. Thus any growth laid down on the tree represents net photosynthesis resulting from the solar input. We then measured the amount of growth made in one year on selected sample trees and applied these results to the entire stand. Then by using approximate calorific values for each class of materials we were able to estimate the energy stored in this new growth at 447 x 10^8 calories per acre.

The efficiency of conversion can be obtained by dividing the amount of energy fixed by the energy input. In this example it amounts to about 1.6 per cent. This compares well with the average value for cultivated crops, ranging from 1 to 2 per cent.

How does this woodland production of 20,577 pounds to the acre (see Table) compare with agricultural crops? In Connecticut the annual production of dry matter per acre is 7,400 to 14,000 pounds for corn, 6,000 to 7,900 pounds for potatoes, 3,000 to 6,000 pounds for tobacco, and 4,700 to 6,500 pounds for hay. Thus the current production of this pine plantation is very good compared to other crops. Interestingly, this high yield was achieved on abandoned agricultural land and without intensive care.

Do all forest stands produce at this rate? We think not. Maximum annual production is probably achieved at 20 to 40 years of age. Deciduous trees probably produce less organic matter than conifers. The measurements made on a 6-year-old miniature forest composed of flowering dogwood and hemlock indicated much lower yields. In 1962 dogwood alone produced 7,600 pounds of dry organic matter per acre, hemlock and dogwood mixed produced 7,900 pounds, while hemlock alone produced 9,500 pounds. Although these figures include only the material above ground, even a generous 10 per cent increase for root growth would not give yields as great as red pine.

The dense, uniform stand of red pine.

Current annual growth of 27-year-old red pine

	% of total	*lb/acre*	*10^8 cal/acre*
Needles	23	4,800	109
Bole wood	44	8,991	207
Bark	5	993	
Branches	20	4,196	91
Roots	8	1,597	40
		20,577	447

What provides this apparent superiority of trees over field crops? Undoubtedly the perennial growth habit is an asset, the trees benefit from accumulated capital. For conifers the evergreen habit also helps. Finally, trees may be able to utilize a longer growing season than many agricultural crops.

All of these factors combined could account for this greater production. Therefore, this work represents only a start toward determining our most productive forest species and the conditions which affect yield, a part of our overall study of plants in relation to their environments.

New Publications

Publications listed below have been issued by the Station since you last received Frontiers. Bulletin 658, "Effect of Defoliation by the Gypsy Moth," presents information based upon comprehensive studies made in New England by Baker, Tierney, and House between 1912 and 1958.

Entomology

B 658 Effect of Defoliation by the Gypsy Moth, edited by Neely Turner.

C 223 The Chinch Bug and Its Control, John C. Schread.

Genetics

B 657 Connecticut Hybrid Chestnuts and Their Culture, Richard A. Jaynes and Arthur H. Graves.

Report on Inspections

B 654 Commercial Fertilizers, 1962, H. J. Fisher.

IN THE NEWS

C. I. Bliss

Dr. Chester I. Bliss, biometrician at the Station, has been elected an Honorary Fellow of the Royal Statistical Society, London. His election was in consideration of eminent services rendered to statistics.

Few men have been so honored by the Society. In 1961, for example, there were only 27 elected Honorary Fellows.

Dr. Bliss became biometrician at the Station in 1940. His scientific publications number well over 100.

His work is recognized around the world. In 1962-63 he visited 29 countries and gave 110 lectures and seminars. He is president of the Biometric Society, an international organization with more than 1900 members. At the 5th International Biometric Conference at Cambridge in September, Dr. Bliss gave the reply to the welcoming address of Lord Hailsham, Minister of Science.

Hubert B. Vickery

Dr. Hubert Bradford Vickery retired on June 30 after 41 years on the Station staff, 35 of them as head of the Department of Biochemistry. He was elected to the National Academy of Sciences in 1943. Dr. Vickery is the author or coauthor of a notable series of papers on proteins, amino acids, and the metabolism of organic acids in leaves. As Biochemist Emeritus he continues his research at the Station.

Ross A. Gortner, Jr.

Wesleyan University has named Dr. Ross A. Gortner, Jr., professor of biochemistry, as its representative on the Board of Control, the policy-making body for the Station. He replaces Dr. Joe Webb Peoples on the Board.

A. E. Dimond

Dr. A. E. Dimond, head of the Station Department of Plant Pathology and Botany, is the new president of the American Phytopathological Society, a professional organization of the more than 2200 scientists in the field of plant pathology. He is the third Connecticut Station pathologist to head the 55-year-old Society. Dr. Saul Rich of the Station has been elected councilor-at-large for 1964.

Raimon L. Beard

Dr. Raimon L. Beard took part in a World Health Organization conference on culture of insects and their biological control agents, in Florida, September 31 to October 4.

From the Director

James G. Horsfall

Whatever be the future, we must eat (and some say drink) if we are to be merry. From whence comes our food now? Twenty-seven of us are fed by one farmer. The American system that accomplishes this is wonderful to behold. By contrast only two people are fed by each Asian farmer. But from whence will come the food for our children and their children? As a biologist this question needles me.

The demographers say that our population will double in 40 years. The census takers say that a million acres of agricultural land is being engulfed by cities and their environs every year. Can we double our food supply in 40 years from 40 million fewer acres? This question is no idle exercise in alliteration. It is dead serious. Will agricultural efficiency double in 40 years so that 54 of us can still be fed by one farmer? If it does not, we eat less well or some of us will have to return to farming. If so, will we have enough land?

My friends tell me that scientists will save us. By scientists they mean me and my colleagues at the Station and others in research. This faith in us, the biologists, needles me, too. My friends seem to think that we can continue to prove Malthus a poor prophet. How can we do it? And how long will it take to know whether we can?

We don't rightly know, nor does anyone. As an indication, suppose we look at three examples of many from our research in the past.

Plants lie at the base of the food pyramid. We work with plants, both because they give us our daily bread and because they are in large measure the makings of ham, lamb, or steak up near the apex of the food pyramid.

The basis for our research has always been to try to understand how plants grow. If we in science know how plants grow, farmers can grow better plants (and better flowers to grace the table, too).

EPOCHAL DISCOVERIES

This principle of research led us early in our history to the epochal discovery that amino acids are essential in the diet. From this concept soon came the equally epochal discovery of the first vitamin. About 15 years elapsed before these discoveries were really put to use. These discoveries did not lead to more food from plants but to better food. And so boys grow taller than their fathers; domestic animals are more productive than their ancestors.

A few years later our study of plants led to hybrid corn, a discovery that added here in Connecticut and elsewhere about one-third to yields of that crop and thereby to the supply of milk and meat and butter that come from cows. Note, however, that this did not occur overnight, either. With all our American know-how in plant breeding and agricultural education it took about 25 years for hybrid corn to replace the open-pollinated varieties. Note also that hybrid corn added only one-third to corn yields, (and yet it is often cited as the outstanding single agricultural discovery of this century).

Our research theory led still later to a third major discovery, the nabam series of fungicides for controlling plant diseases. This discovery was widely adopted in about 10 years, and it also added about 30 per cent, not to the supply of corn, but to the yield of potatoes and vegetables in Connecticut and around the world.

These three examples of the practical payoff from study of plants suggest three facets of research: (a) there is a long lag time, (b) the big discoveries are a long time in the making, and (c) they seem to have come in spurts.

Our work is essentially a continuing search for ways to produce food. This search for production capability is not unlike prospecting for reserves of oil and sulfur, both essential to our present way of living. The prospectors, too, sink dry holes among the gushers and the sulfur domes. You and I hardly worry about where our next year's supply of sulfur is coming from — we assume that there will be plenty of paper and tires and superphosphate and scores of other products made possible by sulfur. Manufacturers must be concerned. You and I as citizens of Connecticut hardly worry about where our future supply of food is coming from. But, as a biologist I must be concerned.

Only a few years ago this nation was running very scared on sulfur. The prospectors found a new sulfur dome and the sulfur famine was postponed. Sulfur prospecting continues. We biological prospectors will discover other caches of food, and we, too, will continue. A research laboratory cannot make a major discovery simply because the need is great, however. It comes from a continuing search through thick and thin.

In the meantime we in America go to bed at night with our bins and bellies full. We live indeed in the fat years. May the lean continue to be something we only read about in the Old Testament!

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