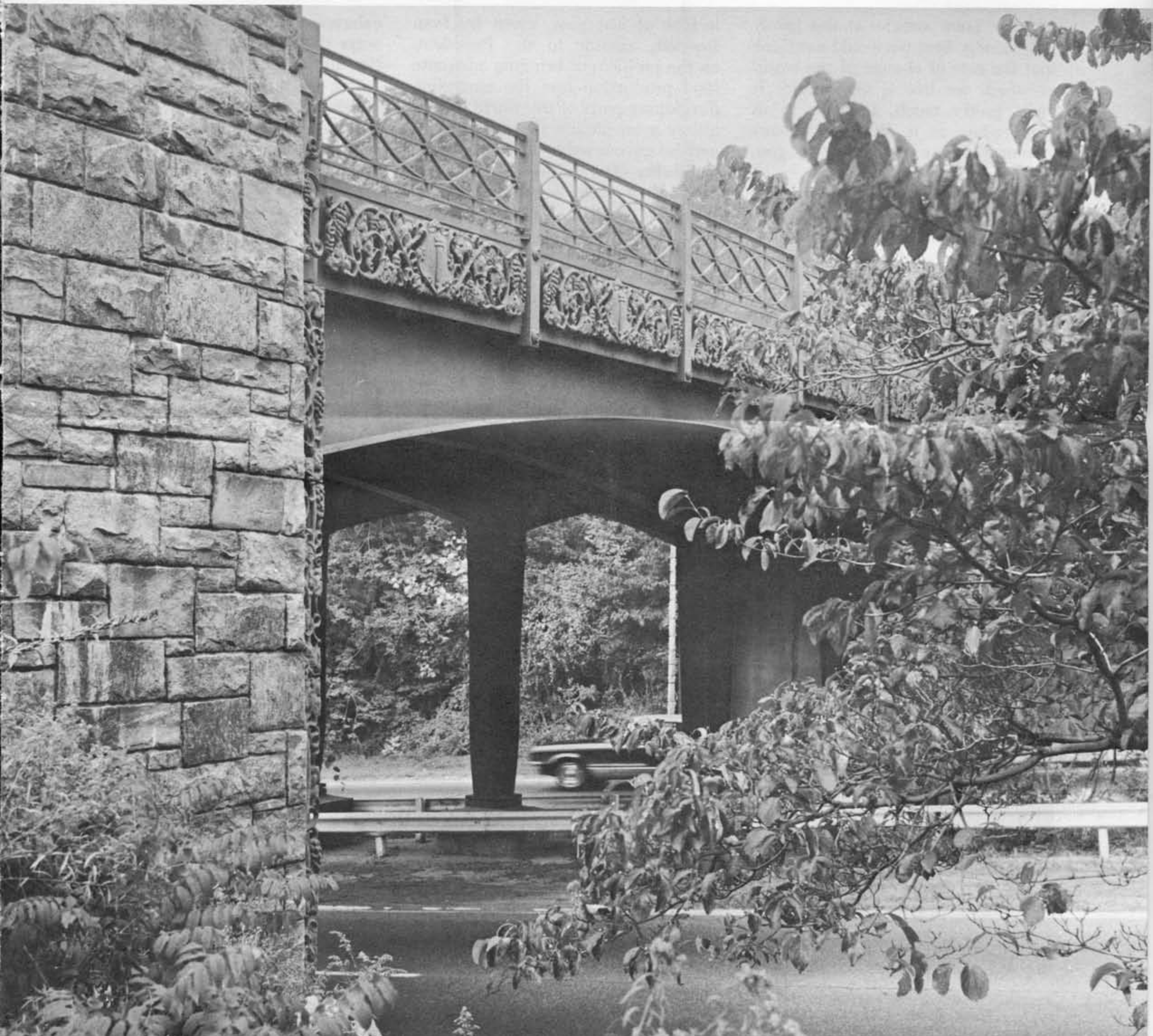
FALL 1968

Frontiers of Plant Science



The Merritt Parkway

"Our new world does not have to be ugly . . ." page 2

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

Hopes and Fears for the Year 2000

Walter Sullivan

As we look around at this lovely scenery here we would not think that the rate of change of the world in which we live is very rapid. It looks pretty much, I think, to us here today, as it did a few years ago or perhaps almost a few generations ago.

And yet, if we think of the enormous changes that have taken place from the days of our grandfathers, we have a very vivid impression of the incredible rate of change of our world. Through the thousands and hundreds of thousands of years of man's history on this planet, always the men who were alive at any one time were living in a world that was indistinguishable, really, from that of their grandfathers or their great great grandfathers.

But before we think about some of the wonderful things that *may* and perhaps even we hope *will* take place, let us soberly think that there are very serious grim alternatives.

My mind goes back to the Johnson lecture of last year, given by Ivan Bennett, advisor to the President, on the problem of bringing adequate food production into the emerging, developing parts of the world. It was a very grim picture that he painted, and he gave a sober warning of the possibility of widespread famine because their technology, their transportation systems, their agriculture, and their social structure cannot keep pace with their growing populations.

Walter Sullivan, left, and James G. Horsfall

And for every man, woman, and child on this planet, the nuclear weapons arsenals provide a nice little kitty of twenty tons of TNT in nuclear weapon yield. So this nuclear "sword of Damocles" hangs over our heads, as we've all become very tired of hearing. Man is adaptable when his back is to the wall—he seems to be able to avoid committing national suicide—but we cannot be assured of this.

Technology and medicine also make possible all kinds of horrible things far worse than those that were conceived of in the book "1984": drugs that give the rulers control over the mind, a society in which we finally become sort of jellyfish sitting in front of the boob tube.

There are other possibilities—I won't go through them all. There is the possibility of epidemics as we allow the population to become so dense that a virus or other organism against which we have no defense, can sweep through the population before we can bring it under control. There is the possibility that we will exhaust all of our raw materials in ways that would cause our civilization to collapse.

But I am an inherent optimist, I believe we can conquer all of these dangers, though there may be stresses and strains and a certain amount of agony in the process, and emerge into a 21st century which will be an extraordinary century indeed.

Looking ahead to the 21st century, the Atomic Energy Commission recently came up with a prognostication built, naturally enough, around nuclear power plants. But this was a rather exciting concept of these atomic industrial complexes set here and there all over the country, each built around a plant. Hopefully they would have fusion, which means clean atomic power, power of the hydrogen bomb rather than that of the atomic bomb, using this power to do an extraordinary variety of things that are economically impossible today. Important among these is desalinizing water, providing water at a low enough cost to be used for irrigation in areas that are completely untillable at this point. And industrial processes. If you have abundant energy cheap enough, you can refine metals, you can do all kinds of things in ways that are much simpler than the methods used today and bring a revolution in industry in this manner.

But I think to most of us, one of the most exciting things is the prospect of taking all of the refuse of our civilization and breaking it up into its component parts and reusing virtually all of this material. Instead of dumping it underground, taking it out to sea, and dumping it into our rivers, it would be reduced largely by electrical means into its com-

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Walter Sullivan is science editor of the New York Times. *This article is a part of the lecture he gave at Lockwood Farm on August 14, 1968.*

ponent parts. When your TV set went bad, it really would be cheaper to throw it into the hopper and have it ground up and broken down into its component metals and plastics, than to pay the enormous price of having a TV repairman come and tinker with it. Or perhaps you would throw away one component of it.

What is going to happen in medicine—of course you can have a field day with that, since we've already entered the era of the transplantation of major organs. We are faced with all kinds of social, ethical, and economic problems. Fantastic problems, really, when you realize that we are approaching the time when we may be able to keep almost anybody alive for an extremely long time if it's worth it. And that means we are really going to have to decide "Is it worth keeping so-and-so alive?"

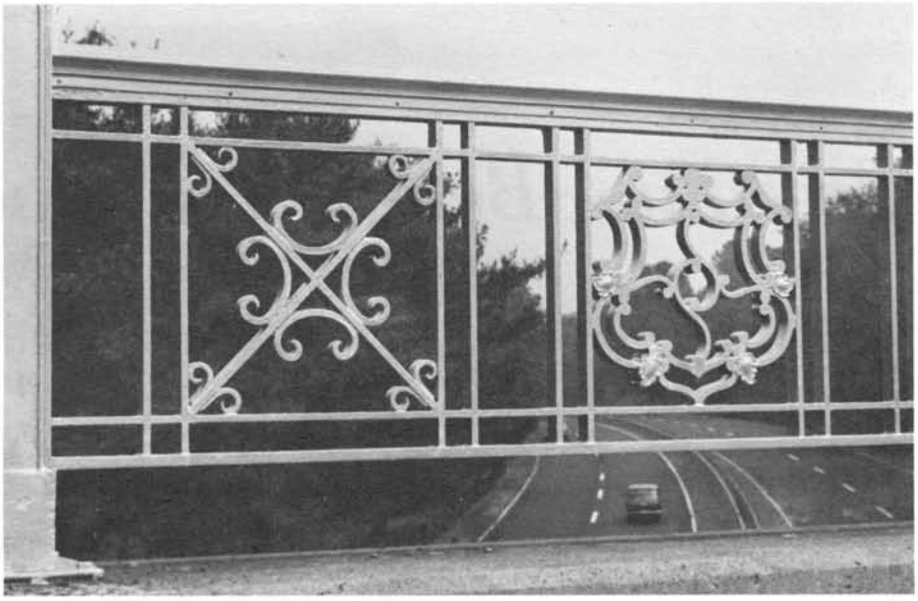
It is conceivable now that the immune reaction will be overcome so that people can be given pigs' hearts. It seems that the pig is probably the best candidate for this; there are lots of pigs around, their hearts are about the same size as the human heart. But imagine the adjustments in attitude that will become necessary if a number of people are going around with pigs' hearts.

A Sobering Thought

The aging process now is the source of very widespread research, and it seems at least conceivable that we will learn what it is that causes aging. If we learn to control this process, then comes a sobering thought. Not only are we faced with the problem that if we spend enough money on somebody he can be kept alive almost indefinitely, but you then have a world in which there are almost no children. I'm not sure that I would want to live in a world with almost no children.

The most sensational current development in genetics to me is the work that is going on at Oxford University in England.

They can take a cell from the intestinal lining of a tadpole and grow an adult frog from it. If this can be done with frogs, there is no basic reason why it could not be done with people. If we wanted to, perhaps we will be able to produce Sophia Lorens by the hundreds of thousands or Albert Einsteins or anybody else we think we like very much. Imagine the social problems raised by this. If there were millions of Sophia Lorens running around perhaps we would get tired of them.



"They were still trying a little bit to put beauty into the bridges . . ."

Well, these are some of the things that perhaps lie ahead of us. The challenge to us is obvious: to produce generations of citizens with the wisdom, with the sophistication, with the knowledge to deal with the incredible problems that all of these capabilities that are not so far over the horizon will present for us.

What science can do for us is to give us the tools to deal with some of these problems. It is very appropriate in this place where science is at work every day, where Samuel W. Johnson established the first Agricultural Experiment Station in the country, to think what science can do for us in general terms.

Science, for example, can seek out the roots of our destructively aggressive behavior and perhaps find ways in which we can condition people so that their destructive aggression becomes constructive effort—constructive aggression if you will. Science can arm us with the energy that we need to solve many of our social and economic problems, to build a world in which there is no poverty.

Science can tell us how more effectively to educate our children. Asoka Mehta, who was Minister of Planning in India, made a comment on the problems of education today that I found very much to the point. "In former times," he said, "a teacher could provide his students with a map to guide them through life. Now the best thing he can give them is a compass."

And science can help to teach us how to give them an effective compass. Science also can erode our provincialism—our excessive nationalism—through the medium of earth satellites that bring our most distant neighbors on this planet into our livingroom; through supersonic jets (I would settle for ordinary jets) that bring all parts of the world within our backyard, so to speak. Having seen our most distant neighbors at close hand, a person can never speak of a foreigner again with quite the same disdain.

I believe that science also, and I mean to include technology, can bring about a new Renaissance by eliminating poverty, by eliminating the struggle to live "well"—but at bargain rates. Technology that has made possible the mass production of tawdry goods, can also produce goods of quality. Our new world

(Continued on page 5)

Breeding Better Tomatoes

Carl D. Clayberg
Genetics

Measured in terms of cash receipts to farmers, tomatoes are the second most important vegetable crop in the United States. Growers received more than $433 million for their crop in 1967. In Connecticut the crop is important to the growers who sold nearly $1.7 million worth last year and to the food suppliers who keep Connecticut consumers supplied with tomatoes and tomato products year-round.

The tomatoes you buy today are products of a technology that draws heavily on research in genetics. This Station has long contributed to the pool of knowledge that tomato breeders must have. As in so many other fields, Connecticut produces and imports better products because it originates and exports usable ideas. In the accompanying article, Dr. Carl D. Clayberg suggests how his research on tomatoes ties in with that underway elsewhere.

THE PAST FEW YEARS have seen a remarkable shift in the types of tomato varieties grown in much of the United States. Practically all of this change can be attributed to the advent of mechanical tomato harvesters. The shortage and high cost of farm labor led to mechanizing the harvest of other important vegetables some time ago. This has been slower to happen with tomatoes because they are highly perishable. Problems have been overcome, however, by designing machinery and breeding tomato varieties specifically suited to each other.

Processing tomato varieties, the only kind now being machine harvested successfully, used to be large bush types. Their tomatoes ripened over several months and the ripe fruit had to be picked every few days. But mechanical tomato harvesters operate by cutting off the plant at ground level, elevating it, and shaking the ripe tomatoes off onto moving belts for sorting. Therefore, new plants had to be bred—plants that are smaller and ripen all of their fruit at one time. Mechanical harvesting also calls for firmer fruit less susceptible to bruising.

Varieties possessing these traits have been developed and now constitute the majority of those grown in California, the principal processing state. In the east where acreages are smaller and fields may be wet from rains at harvest time, the need is for smaller, more maneuverable mechanical harvesters. Some have been so designed and undoubtedly will become important in harvesting eastern tomatoes.

Fresh market tomato varieties suitable for mechanical harvesting have yet to be developed. This market requires fruit undamaged by harvesting or packing to prevent the tomatoes from spoiling on the way to often distant markets or while on the shelf awaiting sale. So there is a need for varieties with firmer, more meaty flesh and a skin more resistant to abrasion and cracking than is true of varieties presently grown. As with processing tomatoes, fresh market varieties for mechanical harvesting will have to be small determinate vines—the types I am developing here in Connecticut.

The way the tomato fruit detaches from the vine presents another problem for mechanical harvesting. Normally, the fruit stem, or pedicel, separates at a natural breaking "joint" in its center, leaving a piece of stem and the calyx attached to the fruit. These short stems, if left on the fruit, would puncture adjacent fruits after they are shaken off of the plant during the harvesting process. For this reason the stems must be removed, but removal by hand is prohibitively expensive. Consequently, breeders are attempting to develop varieties lacking the pedicel joint. In its absence the stem breaks off where it joins the fruit, leaving the fruit completely free of stem.

Two genes are known that cause the joint to be absent. The first of these was of no practical use because in varieties possessing it the stems often did not break off cleanly from the fruit and the end of each flower cluster was leafy, reducing the number of fruits produced. The second gene causing jointless stem was found a few years ago in a wild tomato collected on the Galápagos Islands. This gene seems to be free of defects and is being used by breeders of fresh market tomatoes for machine harvesting.

Whether developing tomatoes for mechanical or hand harvesting, breeders are concerned with making varieties disease resistant. Since there are highly effective chemical sprays for the control of most fungal diseases of tomatoes, efforts have been directed primarily towards the development of varieties resistant to those diseases for which there is no spray treatment. Increasingly, the newer varieties carry combined resistance to two major soil-borne fungal diseases: Fusarium and Verticillium wilts. Neither of these wilts is easily or inexpensively controlled by soil fumigation, the only alternative to using resistant varieties.

Tobacco Mosaic Virus Costly

An equally serious disease of the tomato is caused by tobacco mosaic virus. Depending on when the plants are infected, the strain of the virus involved, and climatic factors, the reduction in yield will range from 10 per cent to total loss of the crop. At present the only control is early removal of infected plants and destruction of weeds at the edges of the field, as these weeds can serve as reservoirs of virus to be transmitted into the field by farm machinery or insect pests.

Genes for resistance to tobacco mosaic virus have been found in wild relatives of the tomato. Several of these genes either do not provide adequate levels of resistance to the virus or cannot be separated from undesirable plant characteristics. A gene for resistance recently discovered by Dr. L. J. Alexander of the Ohio Agricultural Research and Development Center at Wooster is now being transferred by plant breeders throughout the world into tomato varieties in the hope of controlling this most serious disease. I am putting it into early fresh market varieties in which I have previously combined resistance to Fusarium and Verticillium wilts.

Improvement in fruit quality and convenience is also of concern to the tomato breeder. The trend towards firmer-fruited tomatoes, which has been accelerated by the need for fruit suitable for mechanical harvesting, will lead to more meaty tomatoes, superior for slicing. Dutch scientists, using irradiation to induce potentially useful mutants in the tomato, have recently obtained an easy peeling type whose skin can be readily removed without the need for first dipping the fruit in hot water, as is now done. This mutant may be valuable in varieties used for the canning of whole tomatoes and in varieties for the home garden.

Several genes are known which increase the amount of red pigments, lycopenes, in ripe tomatoes, thereby intensifying their color and making them more attractive. Breeders of canning tomato varieties have been making use of these genes to improve the color of the processed fruit. I am transferring them into early fresh market varieties, because these often do not develop tomato fruits as red as those produced by varieties of later maturity.

Increasing Vitamin Content

A gene that converts the lycopenes of red-fruited tomatoes into beta-carotene, an orange pigment from which Vitamin A is formed, increases the content of this vitamin ten-fold in orange-fruited tomatoes having this gene. Although orange-fruited varieties are less popular than red-fruited ones, the high Vitamin A content of tomatoes having this gene makes them an important source of this vitamin. Most orange-fruited varieties now available do not possess this "converter" gene and do not differ in Vitamin A content from red-fruited varieties. I am putting the gene into early market varieties suitable for the specialty market gardener and the home garden.

It is clear that tomato varieties today are being improved at an unprecedented rate. Breeders are testing large collections of wild and cultivated tomatoes, looking for new sources of disease and insect resistance. Chemicals capable of inducing mutation are being widely used in the hope of obtaining horticulturally useful mutants. All of these efforts will ensure that the tomato continues as a vegetable of major importance for many years to come.

Hopes and Fears

(Continued from page 3)

does not have to be ugly, despite what has grown up around us during the past two decades—the "bargain highways" and "discount drags" with their pizza parlors and filling stations. You would think that we have forgotten to love beauty, but if we had sufficient wealth we could afford beauty. I believe we could build a new and wonderful world.

You remember when they built the Merritt Parkway, they still were trying a little bit to put beauty into the bridges that span it. Each one is a little different, some have grapes hanging from them and some have curly iron work and so forth. Today, of course, our thruway bridges are the most standardized, utilitarian, and ugly things you can imagine.

But as we enter the 21st century, I believe if we do not have a nuclear war, if we can bring the rest of the world up with us, if we can solve the enormous problems of our own cities, that then we can build a world with sufficient leisure so that creativity will flourish again, so that we will make ours a beautiful world. A man at the University of Michigan named John Platt, a professor of physics, made a comment recently that I think sums up the whole situation in a nutshell. "The world," he said, "has become too dangerous for anything less than utopias."

New Publications

The publications listed below have been issued by the Station since you last received Frontiers. Address requests for copies to Publications, The Connecticut Agricultural Experiment Station, Box 1106, New Haven, Connecticut 06504.

Plant Pathology

B694 *Aldehyde Traps As Antisporulants for Fungi.* James G. Horsfall and R. J. Lukens.

Entomology

B695 *Termites in Buildings.* Neely Turner.

Tobacco

B697 *Chemical Control of Weeds in Connecticut Tobacco.* John F. Ahrens.

An air-purification plant closes down for the winter.

Plants As Air Purifiers

Saul Rich
Plant Pathology and Botany

PLANTS PROVIDE US with food, shelter, clothing, and lovely landscapes. They also provide us with the breath of life. Plants purify the air.

First of all, what is air? Air is the mixture of gases which covers the earth. The air in which we can survive without special equipment is only the 6 to 8 miles of the atmosphere next to the earth. Compared to the 8,000-mile diameter of Earth, this vital layer of gases is only a thin skin at the boundary between the earth's surface and outer space.

Air is essential to us because it contains oxygen, a gas which we need for life and which we would think about only if it began to disappear. Where does this oxygen come from? Not from outer space or from the depths of the earth. Oxygen in the air comes from green plants, and *only* from green plants.

Earth scientists tell us that there was no free oxygen in the atmosphere when the earth was formed. Although oxygen is our most abundant element, it combined with the hot, flowing rocks and metals that formed the earth, and with hydrogen to form water. No free oxygen remained in the primordial atmosphere.

For nearly the first 4 billion years of the earth's existence it was without life or atmospheric oxygen. The first successful life forms, which began to appear less than 1 billion years ago, must have been tiny microbes which could exist without free oxygen. From these anaerobic microbes, living in the waters of the earth, tiny plants evolved which could use the energy of the sun to change carbon dioxide and water into food, and release oxygen gas. Since oxygen is not very soluble in water, the gas bubbled up into the atmosphere. As plants became more numerous, the oxygen content of the atmosphere increased, allowing the development of life as we know it. The air that we breathe is about one-fifth oxygen gas, and plants are still our only source of atmospheric oxygen.

If the oxygen in Connecticut air came only from Connecticut plants, we would suffocate when most of our vegetation closes up shop for the winter. Fortunately, great masses of air move up from the equator, down from the pole, and sweep across the oceans. The oceans, which

Leaves filter out air-borne particles, trap poisonous air pollutants, and trade carbon dioxide for oxygen.

occupy three-fourths of the earth, teem with tiny green plants called phytoplankton. These tiny plants are so numerous that they supply a large portion of the oxygen entering our atmosphere. So plants elsewhere in the world still furnish our oxygen when our local vegetation appears frozen and lifeless.

Plants not only purify the air by supplying oxygen, but also by removing carbon dioxide. Carbon dioxide is a gas produced whenever we burn fuel for heat or energy, or incinerate our rubbish.

The tremendous amount of burning that we do to power our industrial nation has alarmed some scientists. They point out that putting too much carbon dioxide into our atmosphere may cause drastic changes in the earth's climate. What happens to the carbon dioxide? Our atmospheric carbon dioxide is kept in balance in two ways. The first is the combination of carbon dioxide with salts in the sea to become carbonates, and the second is its uptake by green plants which need this gas for photosynthesis.

It is an intriguing thought that an excess of carbon dioxide may increase our food supply. Crop scientists at The Connecticut Agricultural Experiment Station and at other laboratories have found that many plants grow better when given more carbon dioxide. Who knows, perhaps the extra carbon dioxide from industry may be helping to increase our agricultural productivity.

Where trees and other plants cover the land, their vast areas of leaves adsorb and filter out large amounts of soot, dust, and other annoying particles floating in the air. Any particles that settle on the leaves are no longer in the air for us to breathe. Once on the leaves, the particles stick there and are washed down around the roots of the plants by the rains.

Green leaves also trap many of our gaseous air pollutants such as sulfur dioxide, ozone, and peroxyacetyl nitrate. Plants are injured when they take in too much of these pollutants, but they continue to absorb these toxic gases as long as functioning leaf tissue remains. The ability of plants to remove air pollutants is one of the important reasons for preserving greenbelts in our cities and towns.

So far we have discussed the role of green plants as air purifiers. It is entirely possible that bacteria, which are also plants, may be keeping us from self-destruction by helping to remove carbon monoxide from the air.

Carbon monoxide is a poisonous gas produced by the incomplete burning of many fuels. It is the most abundant of all the poisonous air pollutants resulting from man's activities. The tons of carbon monoxide spewn into the American atmosphere each year exceeds that of all the other air pollutants combined.

Carbon monoxide is relatively stable and only very slowly oxidizes to carbon dioxide. Still, in spite of the tremendous increase in yearly emission of carbon monoxide, there has been no accumulation of this toxic gas. Where does it all go? It is surprising, and somewhat frightening that no one is quite sure. Scientists at other laboratories have proposed that certain bacteria in the soil help to remove carbon monoxide from the air. If this be true, we are indeed indebted to tiny, unseen myriads of plants—the phytoplankton that replenish our oxygen supply and the bacteria that trap deadly carbon monoxide.

Waggoner and Anderson Promoted, Turner Retires

Paul E. Waggoner

John F. Anderson

Neely Turner

PAUL E. WAGGONER, head of the Department of Soils and Climatology and a member of the staff since 1951, will become vice-director of the Station on January 1, 1969. Dr. Waggoner's investigations have included studies of the effect of atomic radiation on plant diseases, the relationship between microclimates and plant development, the energy budgets of stands of plants, and water conservation through regulation of the stomata in leaves. He will continue to head the Department of Soils and Climatology.

JOHN F. ANDERSON has been appointed as head of the Department of Entomology and State Entomologist, effective January 1, 1969. Dr. Anderson came to the Station in 1964. His research has dealt largely with studies of sex and anomalous development of mosquitoes. A graduate of North Dakota State University, he received his doctorate from the University of Illinois.

NEELY TURNER will retire in December after 41 years at the Station.

Mr. Turner has been State Entomologist as well as chief entomologist and vice director of the Experiment Station since 1952. A native of Marionville, Missouri, he is a graduate of the University of Missouri.

He pioneered in the investigation of rotenone as an insecticide and in the formulation of crop-protecting dusts, especially the effects of materials used to dilute the dusts. More recently he has explored the reasons behind outbreaks of the gypsy moth and other forest insects.

Mr. Turner is a past member of the Governing Board of the Entomological Society of America. He received the meritorious award given by the Eastern Branch of that society last year. The award cited his "outstanding contributions of broad significance to the science of entomology and his outstanding service to the profession of entomology."

Neely Turner, the Missouri Meerschaum

James G. Horsfall
Director

TIME TICKS BY and Neely Turner tells me that he will soon retire. Words come a little hard on these occasions, for I have known Neely for nearly 30 years. We both came East from Missouri, I a little later than he. We have traveled all the back roads of Connecticut together, working on bugs and blights of vegetables, potatoes and other crops. We have sprayed potatoes together, and it seems as though we must have dug enough of them to fill a freight car.

And then, too, we have sat through meetings and conferences, through dull speeches and brilliant ones. We have met with lawmakers and state officials; with greenskeepers and pest control operators, with garden club ladies and beekeepers. In short, we have worked together through thick and thin.

Now, Neely is an extraordinary character. His professional expertise has enhanced his practical approach to entomological decisions faced by Connecticut farmers and other citizens. His ideas wear work clothes. Along the way during his 41 years in this State, he has made an enviable number of friends. To many, I am sure, he typifies the Connecticut Station approach to entomology, the coexistence of man and insects.

Of course all characters have trademarks by which we know them. If they had no trademarks, we wouldn't recognize them as characters. One knows instinctively that a pipe smoker is a philosopher, but a corncob pipe smoker like Neely is a special breed of philosopher. We expect him to speak, most of the time at least, with words of wisdom that reflect his appreciation of the land. And Neely so speaks.

I suspect that he hollowed out his first cob for a pipe before he was 10 and sneaked a smoke behind his father's barn down in the mountains of Missouri. And I suspect that his father's reaction to this impressed Neely where it hurt. Whereupon, Neely decided then and there that a corn-cob pipe was just what he needed to evoke an image in others.

His mother gave him another trademark—his first name. She didn't choose a standard-brand name like, say, John J. Turner. She didn't strive for alliteration with Thomas A. Turner, nor reach into mythology for Titan Turner. She named him Neely, with no middle initial, thereby causing blank spaces to occur in thousands of state and federal forms that he has filled out. Neely Turner it was. Neely Turner it is. A great many of his friends, in fact, long since stopped referring to him as Mr. Turner. They just call him Neely.

Among these friends is the executive editor of the *New Haven Register*. When Neely was president of the Kiwanis Club, a *Register* story labelled our man Nellie Turner, as not infrequently happens. A mutual friend suggested a correction in the paper. "Too risky," the editor retorted, "it might end up as Neely Turnip."

In no case would there be any confusion. The editor knew that people knew that the man in question was Neely Turner, the Missouri Meerschaum; Neely Turner, the philosopher from Marionville, Missouri; Neely Turner the distinguished citizen of Connecticut.

All his friends in Connecticut, all his friends at the Experiment Stations across the country, and in fact, all his friends in science around the world will join me, I am sure, when I say "Thanks, Neely, and God bless you."

A Note To Readers

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We welcome the 492 new Connecticut readers of FRONTIERS who have requested the publication since May.

Frontiers of Plant Science published in May and November, is a report on research of The Connecticut Agricultural Experiment Station. Available to Connecticut citizens upon request.
Vol. 21 No. 1 November 1968
BRUCE B. MINER, *Editor*

THE CONNECTICUT
AGRICULTURAL EXPERIMENT STATION
NEW HAVEN, CONNECTICUT 06504

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Director

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