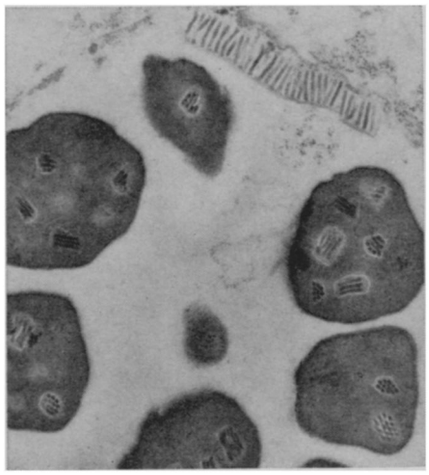
Helping nature control insects

Viruses that kill pests look promising as substitutes for hard insecticides

". . . We should no longer accept the counsel of those who tell us that we must fill our world with poisonous chemicals; we should look about and see what other course is open to us."

The words are Rachel Carson's; they appear in the final chapter of her famous book, "Silent Spring," and they refer to her recommendation that specific biological controls of insect—and other—pests be substituted for the broad-spectrum hard chemical pesticides.

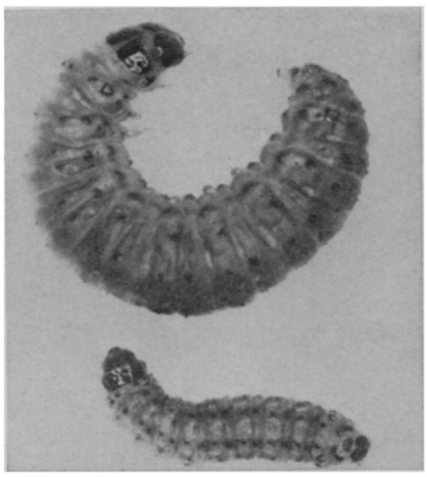
Since publication of "Silent Spring" in 1962, Miss Carson's views on the hard pesticides have become widely accepted, at least in the United States



Viruses in almond moth larvae . . .

and Europe. And work on biological controls has progressed to the point where a number of important advances may be made in the near future.

Miss Carson described the origins of much of the work that is now beginning to pay off; this work has continued quietly in U.S. Department of Agriculture and university laboratories. Some of it has been stimulated by the furor over the hard pesticides. But much of it has been in response to necessity: The major advances have often been against pests that had developed hard-pesticide resistant strains,

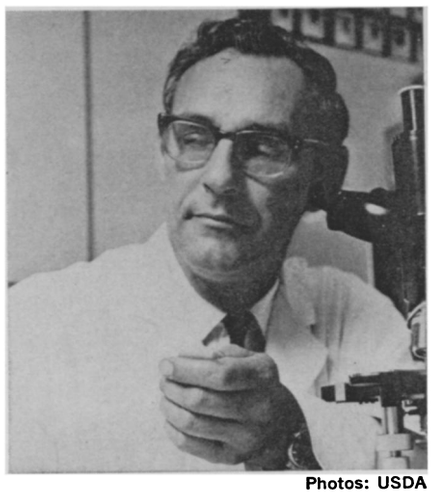


. . . result in stunted growth (below).

or that were for other reasons not subject to chemical approaches.

The main advantage of biological controls is that they are specific, and are very often nature's own way, aided and abetted by man. Thus are avoided the environmental contamination and the gross disruption of the ecology caused by chemicals. For example, if a specific biological control could be found for the boll weevil, a major cotton pest, then the hard pesticides that are now used against the weevil would not kill predators of the cotton bollworm, another cotton pest, and the need for pesticides could be reduced further. "Biological controls are analogous to picking off a criminal in a crowd of people with a high-powered rifle," explains Dr. A. M. Heimpel, chief of USDA's insect pathology research laboratory, "whereas the hard pesticides are like spraying the whole crowd with machine-gun fire in order to get the one man."

A single major advance in biological controls can have an extremely important effect. USDA hopes to begin within a year an experiment with an integrated attack on the boll weevil, using chemical pesticides first, then sex attractant traps and, finally, sterilized males. If the experiment is successful



Photos: USDA

Dr. Heimpel: Rifles, not machine guns.

and can be commercially applied, it might reduce total hard pesticide use in the United States by one-third, says Dr. E. F. Knipling, director of USDA's entomological research division. "About 80 to 90 percent of all hard pesticides are used against 100 major insect pests," says Dr. Knipling. "The outlook is that we will have specific biological controls for half of these in the next 10 years."

Biological controls fall into three major categories: Pathogens, various microflora or viruses that are natural enemies of insects, but which can be cultivated and applied in far larger numbers than in nature, as well as at the most opportune time; interference with metabolism or reproduction in insects, such as through the sterile male approach, and introduction of natural predators.

There have been a number of successes already; the sterile male approach has been used against the screwworm, a livestock pest (SN: 3/11/67, p. 238); a USDA program to import natural predators of insect pests is also beginning to pay off (SN: 6/27, p. 620).

An International Colloquium on Insect Pathology at the University of Maryland last week discussed the pathogen approach, and it is clear that many advances are being made (see page 194). Use of pathogens against insects is not new; *Bacillus thurmgiensis* has been used against leaf eating lepidoptera in the larval stage for some years and is now applied, for example, to 60 percent of California's lettuce crop (partly because of strict rules against hard pesticide residues on leafy crops). *B. thurmgiensis*, a spore forming bacterium, acts by forming a protein crystal that is a specific poison for lepidoptera. The crystal either kills the larvae, or makes them more susceptible to infection by the bacterium.

But this organism attacks all lepidoptera and thus is not really specific; in addition, the bacterium does not kill

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all members of an infestation. Thus, a successful biological attack on, say, the cabbage looper, a pest nearly out of control in Arizona, might involve infection with both the bacterium and a virus specific for the insect. " I envision a day when integrated control might involve many approaches to one insect pest," says Dr. Heimpel. "Included might be insecticides, parasites, predators, bacteria and viruses."

There are about 18 viruses now isolated which have a high potential as insecticides, and viruses are the most promising new approach; the Food and Drug Administration will soon approve the first large-scale experimental use against a specific pest—the corn earworm—in the United States.

There are several types of viruses that have been found to be natural enemies of insects, each of which has a specific mode of attack. Most of the viruses are highly specific for the insect they attack; but because of this specificity, the viruses are hard to produce: They must be raised on the host insects, and insect-rearing facilities are far more complicated and expensive than the fermentation tanks in which bacteria are grown. (However, Dr. James L. Vaughn of the insect pathology laboratory is rapidly closing in on methods for producing insect tissue cultures on which the viruses could be grown.)

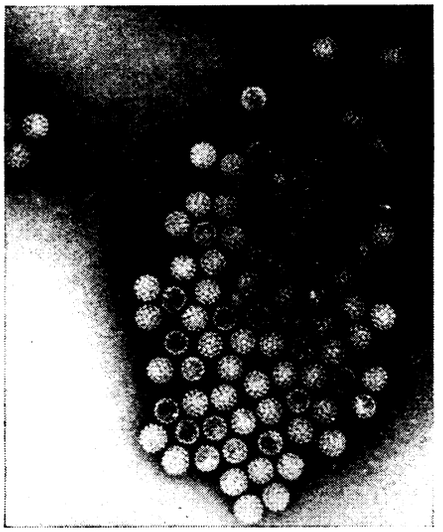
Dr. Heimpel estimates it costs about $2.5 million to get into commercial production with a viral pesticide, about the same as for a new chemical pesticide. But Dr. Knipling points out that a new chemical might attack dozens or more insects, whereas a viral agent is usually specific only for one.

Comparisons of costs between biological and chemical controls are, at best, difficult. Generally, biological controls are more expensive to develop and produce. "But the biological controls are much more economical in the long run," says Dr. Knipling. He explains that once suppressed biologically, insects require only small amounts of the suppressant to keep them in check. With hard pesticides, insects are back the following year in the same, or even larger, numbers. Also, biological controls can often reduce damage by 100 percent, as opposed to smaller reductions with chemicals.

But there are problems. Biological controls often must be applied on a region-wide basis to be effective, instead of on individual farms or orchards as with the chemicals. And the shift required in the pesticide industry is difficult, too, because of the uncertainties and high costs of radically new plants. "It takes a great deal of courage for a company to venture into producing a new biological control," says Dr. Heimpel. □

GENETIC DISEASE

Therapy by virus



Dr. Rogers

Shope virus to fight arginaemia.

Generally speaking, a virus infection is a thing to avoid. Nevertheless, man cannot always dodge the myriad of viruses to which he is exposed.

When a virus infects a cell, its core of genetic information (DNA or RNA) becomes part and parcel of the cell it has penetrated. In most cases, its presence is unwelcome, its effects deleterious. There are, however, times when a man can be infected by a virus and not even know it. Such infections are wrought by so-called passenger viruses, which enter cells without causing any perceptible harm. Among these special agents is the Shope virus. For 40 years scientists have held it to be innocuous in man. Now they speculate that in special circumstances it may be actually beneficial.

A team of European investigators from Berne, Cologne and Antwerp, has deliberately infected two German children with the Shope virus in hopes of reversing the biochemical error in a rare genetic disease known as arginaemia. The two children, aged two and seven, are the only individuals reported with this genetic defect, which is characterized clinically by mental retardation and convulsions and biochemically by high levels of the amino acid arginine in blood.

Unfortunately, there is little expectation that Shope virus infection will alleviate the clinical manifestations of arginaemia. In these two cases, it is probably already too late for that, too late to reverse mental retardation. Experimentally, however, the scientists hope to demonstrate that they can reverse the biochemical defect, reducing blood arginine levels. Thus far, their success is uncertain.

According to Dr. Stanfield Rogers of the Oak Ridge National Laboratory in Tennessee, the children were infected less than four months ago. It is too early to see clear results, although researchers anticipate some indication of whether the Shope virus is inducing the desired arginine-lowering effect by late fall. If it works, it raises the possibility of preventing arginaemia in an individual detected and deliberately infected by virus at birth.

Even more importantly, observes Dr. Rogers, who has been working with the virus in the laboratory and who is in close touch with the foreign team, which includes pediatrician Dr. H. G. Terhaggen of Cologne, the experiment opens the door to the use of viruses to transmit genetic information in man. "The field," says Dr. Rogers, "has fantastic possibilities." Theoretically, viruses could become one of the major tools of future practitioners of genetic engineering. That era is still many years away, however.

Biochemically, arginaemia is an inherited disorder in which the patient is unable to metabolize arginine because he lacks the necessary enzyme—arginase. The small Shope virus, which carries only a few bits of genetic information, happens to carry the DNA triplet that codes for arginase synthesis. Thus, it is likely when Shope virus DNA becomes incorporated into the genetic information of a cell deficient in the gene for arginase, it will fill the gap by supplying the missing gene for arginase synthesis.

Considerable experience with normal individuals accidentally infected by the Shope virus stand behind the presumption that it does no harm. In 1933, Dr. Richard Shope, its discoverer, injected himself with virus. For many years he had low blood arginine levels because additional stores of the enzyme metabolized the amino acid in his body, but there were no other effects. Similarly, innumerable laboratory workers studying the virus are known to have been accidentally infected without harm.

There are two routes to handling genetic diseases by inducing virus infection. The first, Dr. Rogers points out, is to find in nature those viruses which are safe in man but which carry identifiable, specific genes missing in certain diseases, as in the Shope virus and arginaemia. At present, he and his colleagues are trying to determine what other genes are carried by Shope DNA. This, however, is an arduous task, and a broad-scale screening program of large numbers of viruses is unlikely to produce benefits to outweigh costs in time, manpower and money.

Other passenger viruses have been tried in experimental systems but as yet have not produced dramatic results.

Recently, Dr. James E. Cleaver of the University of California Medical