What Are Pesticides Doing to Human Beings?

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"Nothing!"—say the publicity agents of the insecticide manufacturers. "Hysterical alarmists" is the quaint description applied to some of those who even suggest that the public is being harmed by their use. Groups urging that the newer pesticides not be released commercially until proven harmless to humans by exhausting testing, have been accused of obstructing research and scientific progress!

"Nothing to worry about!"—repeat most of our entomologists. Pesticides are poisonous. Yes. But with proper precautions those handling them are safe. And with the establishment of tolerances for residues on food the public is protected. Moreover, farmers can not bring to harvest the large crops needed throughout the world without the **newer** pesticides. Better the risk of some toxic residues on our food than widespread crop failure from insect attack. These conflicting statements remind one of the cheery whistle adopted by a small boy when passing a cemetery at night.

"Danger!" Widespread illness from the use of DDT on crops and in homes. This is the belief of a few keen observers in the medical profession. A handful of agriculturalists, entomologists and others agree. There is no question at all in the minds of those who have personally experienced DDT poisoning.

How may we account for such marked divergence of opinion? It is not difficult. The manufacturing companies are concerned with a booming business. The entomologists' responsibility lies mainly in protecting our crops from insect pests. Both groups are loath to accept evidence which might interfere with the production and use of the new insecticides. Knowing that some individuals exposed to large amounts of DDT remain in apparent good health, they refuse to believe that small, or even large, residues on food might be harmful to the general public.

Physicians, on the other hand, are primarily concerned with the health of the people and are quick to sense the threat of new poisons added to the diet. This is particularly true in view of the fact that DDT is very stable and may be concentrated in body fat up to at least 30 times the level in the food consumed. Unfortunately, scientific proof of toxicity to humans from low levels of intake is difficult.

The potential hazard to health is tremendous. It must be recognized by all parties concerned and controlled **until the facts are established beyond all doubt!**

The Delaney Committee

In spite of the assurance that there is nothing to fear, the public has become alarmed over the widespread use of poisonous sprays and dusts on our crops. And rightly so.

This alarm was communicated to the Congress which appointed a Select Committee to Investigate the Use of Chemicals in Food Products. The chairman is John S. Delaney, M.C. In addition to pesticides, this Committee is investigating the use of chemicals in other fields, such as drugs, cosmetics, food preservatives, and fertilizers.

For the past two years the Committee has been hearing testimony from prominent scientists, entomologists, nutritionists, food growers, manufacturers, physicians and others interested in the problem.

In the field of pesticides, testimony was overwhelmingly against the idea that the public health was being endangered by their use. However, a few physicians presented convincing clinical and laboratory evidence of widespread illness from contact with DDT on foods or in sprays.

Louis Bromfield was not only convinced of the hazard but from his own experience told the Committee, that with correct farming methods, few insecticides were necessary or desirable.

Recently L. G. Cox, director of technical projects for the Beech-Nut packing company stated that his firm had spent $668,000 in the past six years in an attempt to keep the newer pesticides out of baby foods and peanut butter. He also stated that a fund of $119,000 had been raised by the manufacturing chemists "to counteract unfavorable publicity." Mr. Cox related that in a number of instances his company had been forced to reject large orders of fruits and vegetables because of contamination with DDT, Chlordane and Benzene Hexachloride.

In a preliminary report to Congress in January, 1951, the Committee recognized

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the existence of a definite hazard to public health and continued hearings. These are still taking place. As a result of the evidence it is to be hoped that remedial legislation will be recommended to the Congress.

The purpose of this article is to give the members of the Academy the latest information on this highly controversial and extremely important subject.

Extent of the Problem

For the past thirty years or more there has been a gradual increase in the amount of poisonous chemicals used on crops for the control of insects and fungous diseases. During the same interval a corresponding decrease in the protein content of our plants and the nitrogenous content of our soil has been noted.

Since the introduction of DDT and similar compounds in 1946 the tonnage of the new insecticides in use has tremendously increased, while that of the older chemicals has dropped. The marked toxicity of these new compounds for most insects and animals, together with their unusual stability, has exchanged new problems for old.

It is no exaggeration to say that at the present time, with the exception of fish, it is a rare article of food that has not been dusted or sprayed with one or several poisons before reaching the consumer. Never before has the long-suffering public been made a guinea pig for the mass testing of so many exceedingly powerful chemicals.

Food Contamination

Theoretically crops are treated long enough before harvest so that weathering has reduced the residue below toxic levels. **Practically** this safeguard is of little comfort for the following reasons:

(1) Enforcement of regulations is not feasible except in the case of large farms. It is physically and financially impossible to police all the small farmers. How often has ignorant enthusiasm led to the application of many times the recommended amounts? Who knows? And how many small producers, if faced with the destruction of a crop by insect pests shortly before harvest, would have the fortitude to refrain from spraying at that time? And why should they hesitate? The trade journals tell them any danger to the consumer has been greatly exaggerated.

(2) When airplanes are used for dusting fields, drift to adjacent areas is frequent. This has been reported as leading to innocent, but heavy contamination of some crops.

(3) While our state and federal inspectors are conscientious and hard-working, they are limited in number. One wonders how much food grossly contaminated with poisons reaches the consumer. We know that some does. Spot check tests can discover only a portion of it.

(4) Our knowledge of the long range toxic effects of most of the new compounds is woefully inadequate. Therefore how can tolerance limits be arbitrarily set? Particularly when no tests have yet been perfected for even detecting the most recent ones. Logic dictates that until all the facts are known **any residue** on food is too much.

Other Contacts

As though poisonous residues on food were not enough, the public is exposed to powerful chemicals in other ways.

For some unknown reason—and in spite of evidence to the contrary—we have been sold the idea that DDT and chlordane are harmful for all practical purposes only to insects. The main basis for this impression seems to be these facts: (1) A comparatively few, healthy young men, when exposed to considerably larger doses of DDT than would be encountered in ordinary usage, showed no ill effects. (2) Animals exposed to DDT aerosols came through unharmed except for local irritation. No allowance has been made for the fact that many humans are malnourished, allergic and chronically ill; nor for the fact that the young are particularly susceptible to toxins of all kinds.

As a result of this propaganda, few households are without DDT aerosols or sprays for fly control. And where ants are a problem chlordane (even more toxic than DDT) is used for their destruction. Both of these substances may be encountered in hotels and restaurants. Naturally, contamination of food and utensils is to be feared.

Most commercial tree sprayers use the chlorinated hydrocarbons. In addition to this source of exposure, pleasure drivers on the highways in agricultural areas may be dusted by airplanes.

Is the Public Protected?

At the present time the Food and Drug Administration offers some protection, but only has jurisdiction over interstate commerce. The great weakness of the agency is this—while it has authority to set tolerances for pesticide residues on or in plant and animal foods, under existing law it can not prevent the use of a chemical **before a tolerance has been set and the relative safety of the chemical determined.**

Most of the state laws are similar. Therefore the state agencies labor under similar handicaps.

Potent new compounds are being synthesized at an amazing rate. Rough lethal doses for animal life can be determined in a few months by acute toxicity studies in the rat and larger animals. However, to learn the cumulative effects of repeated

contact with small amounts of a chemical requires careful observation over several generations. This may take two or three years. In addition to being time-consuming, it is expensive.

In the meantime the partially tested pesticide may be manufactured, advertised, sold, and widely used! Is this protection?

It is only fair to state that some manufacturers insist on thorough investigation before releasing a new product. Others are not so careful, partly because they lack the funds and facilities for such work, and partly because the law does not demand it.

Under the present laws any company wishing to use a new chemical in or on food **is not required** to first consult with the Food and Drug Administration relative to merits or potential harmfulness. This agency may confiscate or condemn products only if they contain chemicals **proven to be deleterious.** The inadequacy of this law is obvious, but some illustrations are illuminating.

Agene was used for artificially aging flour over a period of thirty years before it was discovered that dogs fed with bread made from such flour developed "canine hysteria" or "running fits." The use of this substance has now been abandoned by the baking fraternity in favor of a less ? ? ? harmful substance. Denaturation of the proteins and damage to vitamins undoubtedly remains. Incidentally, the United States Supreme Court in 1919 declared bleached flour to be unfit for human consumption. If this judgment is still on the books, why has it never been enforced?

When the second of the "sulpha" drugs, sulphanilamide, was introduced some years ago, in addition to tablets, a liquid preparation was sought. The drug was relatively insoluble in the ordinary solvents, but finally a chemical was found that would dissolve an adequate dose. This was one of the group now used as an anti-freeze in car radiators. Without adequate animal tests the product was marketed. It was condemned only after a number of deaths due to the solvent occurred.

Other examples could be cited. How long must we wait before adequate pretesting may be counted on to prevent tragedies of this sort?

The Older Insecticides

Let us now consider the more important chemicals used for the destruction of pests. First of all we shall discuss those in use for many years—adequate enough to bring tremendous crops to maturity during the recent world conflict.

With the exception of selenium and arsenic, these chemicals do not transmigrate from the non-edible portions of a plant to those parts used for food. Nor do they penetrate to any extent into the fruit or leaf. Therefore, most of the residues may be removed by scrubbing with soap and water and/or by dipping for one minute in dilute hydrochloric acid.

The chronic toxicity of **arsenic** is well known. In small doses it may have a tonic effect. "Arsenic eaters" in the Tyrol feed it to their horses to increase their stamina and eat it themselves for the same reason. The custom is not highly recommended. As the chemical is usually metabolized and excreted in from one to six weeks, high chronic doses are necessary to produce damage.

However, such high contamination may occasionally be found. Livestock grazing in orchards which have been heavily treated with arsenic compounds may show serious symptoms from such fodder. Some years ago the American Medical Association condemned apples from one county in the State of Washington. These orchards had been so heavily treated with arsenic that dangerous amounts of this chemical had been taken up by the roots of the trees and translocated to the fruit.

Arsenic is often applied to fruits in the form of lead arsenic. The limit for the compound on apples was set in 1940 at 3.6 ppm (parts per million). The lead component is more dangerous in small amounts than the arsenic. Lead is stored in the bones at all dietary levels and may cause kidney damage. A high level of calcium in the diet tends to be protective.

Mercury is highly toxic and residual compounds are dangerous. As little as 0.5 ppm may induce storage in the kidney with resultant harm to that important organ. Mercury vapor used to preserve grain in storage has not been shown to contaminate such grain.

Selenium in the soil is absorbed by the roots and transmigrates to all parts of plants. The same process occurs following the application of sprays. This substance may not therefore be used on food crops. It causes abdominal pains, anemia, weight loss and liver damage. Cattle, cropping plants in seleniferous areas such as parts of Wyoming, develop the "blind staggers." This is followed by paralysis and death. Selenium sprays are used only on ornamental flowers.

Flourine compounds are less toxic than lead arsenate. Their toxicity lies in their ability to precipitate calcium in the body. "Cryolite" is used as an apple spray. When so used the shipper is required to wash off the residue. Drinking water containing from 0.1 to 1 ppm has some effect in lowering the incidence of dental caries in young children. Higher concentrations may produce mottled enamel and interfere with the metabolism of bone. The main hazard of flourine compounds lies in mistaking roach powder for baking soda.

Mass poisonings have occurred in institutions from this tragic error.

Nicotine is one of our most powerful, rapidly-acting poisons. One grain is the minimum lethal dose for man and even one-fifteenth of that may cause severe symptoms. It is a nerve poison, causing stimulation which is rapidly followed by depression. The alkaloid is volatile and therefore presents no chronic toxicity. Some of its salts may provide a residue hazard. For all practical purposes it is no problem except to the applicator.

The pyrethrins. These were originally obtained from the petals of a member of the chrysanthemum family grown in the Far East. Synthetic analogues are now available and have similar properties. These compounds are rapidly detoxified in animal tissues and the lethal dose is very high. Therefore, they are comparatively safe. However, they may produce severe asthma or other allergic reactions in those sensitive to ragweed pollen.

Rotenone from derris root is most poisonous to fish and not very toxic to man.

The **thiocynates** of which lethane is an example are absorbed through the skin. They release hydrogen cyanide, a powerful enzyme poison, in the body. Caution should be exercised if they are used as garden sprays. The solutions formulated for the control of flies are of a low order of toxicity for man. Nevertheless, inhalation should be avoided.

Since the introduction of the newer pesticides the use of the chemicals just described has rapidly decreased. The peculiar properties of the new compounds, together with their application to almost all foods, has created a potential hazard to health of unprecedented proportions.

Part II

For practical purposes, the newer pesticides may be divided into two main groups—the *chlorinated hydrocarbons* and the *organic phosphates*. While differing in mode of action and other properties, both types of compounds in sufficient quantity are lethal to all animal life and most insects.

The Chlorinated Hydrocarbons

In 1939 Swiss chemists discovered the insecticidal properties of DDT or dichlorodiphenyltrichloroethane. Soon afterwards BHC (hexachlorocyclohexane), commonly known as benzene hexachloride, was contributed by France and the United Kingdom.

Since that time American ingenuity has developed other compounds of similar type, namely toxaphene, TDE, chlordan, methoxychlor, lindane, aldrin and dieldrin. New compounds are constantly being synthesized.

Although still undergoing investigation, and with some reluctance on the part of

responsible authorities, DDT was released for commercial use in 1945. Farmers, entomologists and manufacturers had heard of the wonderful new insecticide and clamored for supplies. The pressure was great. Early results justified all expectations.

During the latter part of World War II, DDT had received extensive field trials in the protection of our armed forces from typhus and malaria. This was a calculated risk and there is no doubt that the destruction of lice and mosquitoes radically reduced the mortality from these dangerous diseases.

In Southern Europe our troops were dusted with DDT powder for the elimination of body lice. The same treatment vigorously applied to the population of Naples undoubtedly halted an epidemic of typhus fever.

In the tropics whole islands were dusted by airplanes. The unsuspecting mosquitos and flies were decimated. Other insets, bees and birds shared the same fate to a lesser extent.

An epidemic of gastroenteritis and so-called virus hepatitis affected our troops in Manila at the time this city was given the same treatment. The cause was never definitely determined but was attributed to unwashed vegetables acquired from the natives.

In the year 1950 it is estimated that one billion pounds of agricultural chemicals were manufactured. This gives an idea of the problem before us.

Physical and Chemical Properties

DDT is the least water soluble organic compound known to science. This fact helps to explain why chemists assumed —incorrectly as events have proved—that dairy cattle might be safely sprayed or dusted with that compound. It is however, quite soluble in many fats. Its usefulness as a pesticide and its danger, is to a considerable extent dependent upon this property.

DDT is exceedingly stable. It is not normally decomposed by sunlight nor by cooking temperatures. The leaching effect of rain is very slight. Residues on citrus fruits and foliage in California were found to be reduced by only 50% in 40 days. Ten per cent still remained after 90 days. In soil the compound is much more stable. One test plot still shows

heavy contamination six years after one application to the soil.

BHC is a mixture of optical isomers with a musty smell. Its application has been found to produce an off-flavor in potatoes, walnuts and other crops. The Beech-Nut Packing Company has had to reject shipments of peanuts and vegetables purchased for its line of baby foods for this reason. With the exception of its gamma isomer, lindane, the compound is fairly stable. Lindane is the most active fraction and can now be purchased in a relatively pure form.

Chlordan has properties intermediate between DDT and BHC, but on the whole is more toxic. Aldrin and dieldrin are chlorinated naphthalenes of similar nature—dieldrin being the most toxic and residually effective of the present insecticides.

Toxaphene is a chlorinated camphene of marked stability. Methoxychlor shares with lindane the fact that it is relatively unstable and therefore presents less residual hazard. However, one investigator has stated, that with repeated exposure, the toxicity of lindane may increase as much as 100 times! This merits confirmation.

Toxicology

The chlorinated hydrocarbons are *nerve poisons* and their action is associated primarily with their solubility in tissue fats or lipoids. The cuticle or chitinous covering of most insects is water-repellent and seems to protect them from dessication or drowning. The outer layer of this cuticle is of a waxy nature and has a definite affinity for DDT. This fortuitous property renders most insets as vulnerable to contact with DDT as though no cuticle were present. And the marked stability of this chemical presents prolonged opportunity for such contact. Flies readily absorb the compound through their feet.

DDT has a similar action on the nervous system of insects and animals. Over stimulation of the sensory and motor nerves by lethal doses leads to tremors, convulsions and spastic paralysis. Death from exhaustion follows.

Toxicity for Man and Animals

The acute toxic oral dose for animals is about 250 mg/kg. For a 150 lb. man this would be about ½ ounce. The toxicity is enhanced when DDT is dissolved in dietary fat or in oils.

Suspensions and powders applied to the skin are believed to be non-toxic, but symptoms in man have occurred following contact with oily solutions.

The ordinary household aerosol bomb used for flies and mosquitos is thought to be harmless. Animal toxicity only appears after exposure to a concentration 4000 times that found in this contraption. However, Biskind has reported severe reactions to these sprays, probably as a result of hypersensitivity. Recent experiments suggest that repeated exposure may lead to respiratory infection in animals.

Because DDT is poorly metabolized and excreted by animals and is fat soluble, it is stored in the body fat. It is therefore a *cumulative poison.* The amount ingested in food may be concentrated as much as 30 times in fatty tissue. When the diet is contamintaed, DDT is excreted in comparatively large quantities in bovine and human milk, being found primarily in the cream. Thus, cows fed through the winter on hay containing 84-184 ppm of DDT, secreted enough of this chemical in their milk to cause loss of weight in steers drinking it. Their own suckling calves accumulated DDT to the extent of 825 ppm in their body fat. When rats were fed for several years on a diet containing only 1 ppm, they stored up to 30 ppm in their adipose tissue.

Chickens consuming contaminated rations magnify the DDT intake and excrete it in the yolks of their eggs.

It is conceivable that a rapid loss of weight in animals or humans storing large amounts of DDT in their body fat could release enough in the blood stream to cause symptoms of acute poisoning. Clinically this seems to occur.

At this point is should be noted that fat is a living tissue which is continuously being broken down and rebuilt. Moreover, all types of body cells are surrounded by semipermeable membranes containing lipoids, which can theoretically hold DDT. This chemical is known to inhibit one of the oxidative enzymes, cytochrome oxidase and may interfere with the action of others. Therefore this type of storage in body fat is not like keeping butter in a refrigerator. Toxic effects on each body cell even with high dilution are not too remote a possibility.

Pathology

Whereas rats do not show obvious signs or symptoms of poisoning on a ration containing less than 100 ppm of DDT, the inclusion of as little as 5 ppm in the diet over an extended period of time produces minimal but definite liver damage. This is reversible, if all DDT is removed from the diet. Liver necrosis may be preceded or accompanied by fatty degeneration or enlargement. Fatty changes are resistant to treatment with choline. While early stages of damage may be repaired, A. W. A. Brown states, "—but if further chronic doses prevent its regeneration, the detoxication mechanism of the liver for DDT is impaired."

The damage resulting from *severe poisoning* with the chlorinated carbons varies somewhat with the animal and the compound. However, few organs escape. Pathological changes reported include edema

of the brain and spinal cord, slight kidney damage, necrosis of the muscles, stomach and gall bladder, hemorrhages in the heart and gastrointestinal tract and degeneration of the endocrine glands. TDE has a unique tendency to cause atrophy of the adrenal gland.

Symptomatology

Acute DDT poisoning produces, in laboratory animals, a period of nervousness and hyperexcitability, with excessive blinking, cold skin, ruffled fur, lack of appetite and muscular weakness followed by the onset of fine tremors due to muscle fibrillation, particularly in the heart muscle, hind legs and back. Advanced poisoning leads to rapid weight loss, clonic convulsions, paralysis, and death. In addition to these, cattle and sheep develop staring eyes, diarrhea and staggering gait. Symptoms of mild chronic poisoning may include only nervousness and failure to gain weight normally.

Through 1951 a total of only 14 human fatalities due to DDT were reported. Most of these were the result of swallowing, accidentally or with suicidal intent, relatively large amounts of DDT dissolved in oil. A few severe reactions probably of allergic nature have been described. These included two deaths. Six cases of hemorrhagic purpura and one of agranulocytosis were recently reported.

Symptoms resulting from the accidental ingestion of *undissolved* DDT include nausea, vomiting, diarrhea, nervousness, sore throat, joint pains, muscular twitching, impairment of sight and insomnia. Recovery often takes place in a few days, but in one case took as long as twelve months.

Biskind from his observations has added the following: overwhelming fatigue and muscular weakness, peripheral neuritis, shooting pains, areas of skin hyperesthesia, sense of a lump in the throat, severe emotional depression and vague fear, and decreased vibratory sense.

It will be noted that many of these symptoms are typical of the so-called virus infections that have been widespread in the past five or six years.

Biskind has called attention to the fact that the symptoms described during an epidemic of "Virus X" in California several years ago corresponded almost 100% with those tabulated by him in cases of DDT toxicity. As a result of these observations some writers have quoted him as saying that the "Virus X" epidemic was the result of DDT poisoning. Biskind is emphatic in remarking that he "did not, and could not from the evidence at hand, make such a statement." While a virus believed to be responsible for this epidemic has been isolated, similarity of symptoms is conducive to much thought.

Evidence of Danger

At present the harmful effects of the chlorinated hydrocarbon pesticides on Mr. and Mrs. John Q. Public are debatable. The great majority of entomologists believe that residues on crops, in milk and eggs and meat are low enough to be harmless to humans, and that any possible toxicity is overbalanced by the necessity of these chemicals for the production of adequate food supplies. Their conclusions are open to question and I shall cite some evidence to the contrary.

Biskind, as one of the original physicians suspecting toxic effects from the new insecticides, has reported numbers of cases illustrating definite reactions to DDT, chlordan and BHC suggesting both allergic and direct toxic reactions from these compounds. While some afflictions were short-lived, others persisted for many weeks or months.

Pottenger noted that patients who reported gastrointestinal upsets, followed one or two weeks later by respiratory symptoms, often showed mild jaundice and evidence of liver damage. Fat biopsies analysed for DDT varied in content from 0 to 33 ppm. He felt the exhaustion and other associated symptoms could be attributed to exposure to DDT in food or household sprays. There was no question in his mind but that exposure to DDT could cause serious illness including one type of pneumonia.

Pottenger strongly recommends that any foods sprayed in the process of growing, preparation for market, or the final handling, should carry labels to that effect. Let the public know what it is buying.

Krohn and Pottenger in a medical paper awaiting publication, and included in their testimony before the Select Committee of the House of Representatives to Investigate the Use of Chemicals in Foods and Cosmetics, conclude as follows:

(1) The widespread use of chlorinated hydrocarbon insecticides has produced many cases of toxicity.

(2) These insecticides accumulate in fat and principally damage fat containing organs, as the liver and nervous tissue.

(3) In the presence of characteristic signs, symptoms and blood studies, detection of chlorinated hydrocarbon insecticides in a biopsy of the patient's fat confirms the diagnosis of insecticide poisoning.

(4) Chronic toxicity from these insecti-

cides has been observed more frequently than acute toxicity.

The writer has observed a small number of cases with negative fat biopsies but evidence of liver damage, that gave a significant history of exposure. He has also seen several cases of indisputable allergic reactions to these substances.

In other words, the presence of DDT in body fat proves that absorption of this chemical has taken place but does not necessarily indicate actual poisoning from that substance.

However the presence of liver damage favors such a supposition—particularly if more than 5 ppm of DDT is present in adipose tissue.

Contrariwise, an allergic or hypersensitive individual may theoretically exhibit violent reactions to minute amounts of DDT without absorbing measurable amounts. The only criterion necessary for diagnosis is the reproduction of symptoms upon repeated contact.

Sources of Exposure

There is adequate evidence to prove that many foods raised commercially contain at least traces of DDT or similar compounds. These include staple vegetables and fruits.

For all practical purposes DDT does not penetrate through the skin of fruits. However, it becomes incorporated in the skin or rind and can not be removed therefrom by any washing method known. In spite of the loss of nutrients present in this layer the only safe method of avoiding possible high contamination is to peel all fruit.

Beef, chicken, lamb and pork may contain relatively large amounts of DDT if the fodder of these animals was contaminated with the substance. The use of corn husks, pea vines and other heavily tainted sources of livestock feed renders this possibility a real one. Fatty portions of meat contain the largest quantities.

As has been mentioned before, milk, cream, butter and eggs may be serious offenders if contact with sprays or DDT containing food is adequate. Nor is margarine innocent. The vegetable fats in this product may be contaminated as a result of spraying or dusting.

It took many months before it was realized that dairy cattle sprayed for fly control with DDT or BHC in low dilution would excrete these substances in their milk for ten days or more. This even occurred when barns were fogged or whitewashed with DDT in spite of the fact that food bins were covered and the cattle removed. At the present time these chemicals are not recommended for use in dairies or on beef cattle. Instead, lindane and methoxychlor are suggested as substitutes.

Ironically enough, flies in most areas are becoming resistant to DDT. And what is more—once resistant to this chemical they rapidly seem to acquire immunity to others. Authorities therefore, are once again stressing the old methods of control —cleanliness and eradication of breeding places. And so we come full circle once more.

While translocation of DDT from the ground or foliage to the edible portion of plants seldom occurs, enough BHC and lindane may be so transported to give an off-flavor to potatoes and other vegetables. Therefore the use of these chemicals is decreasing.

Exposure to DDT in the home is all too common. Aerosol bombs for control of flies and fleas should be considered unsafe—as should chlordan powder or sprays for the destruction of ants and other pests. A case of poisoning from the latter compound was recently reported in the J.A.M.A.

The increasing use of lindane, DDT and similar compounds in restaurants and other public places by vaporization has been mentioned in a previous report and is attended by definite hazards.

Hypersusceptible individuals may incur damage from contact with outdoor sprays used domestically or commercially. They should be avoided.

Tentative Conclusions

The purpose of this article is not to create alarm but to alert thoughtful persons to the hazards inherent in the use of DDT and allied substances.

At the present time food production in the United States would be disrupted in a few weeks if the newer pesticides were discarded. This would be disastrous. However, the evidence herein presented points out inherent dangers which were not forseen, and if suspected were — and still are — ignored by many of those in responsible positions. More evidence of human toxicity is needed.

Your House Select Committee is doing a fine piece of investigation and deserves encouragement.

PART III

The Organic Phosphates

These compounds were developed in Germany during the past war for use as insecticides. Rumor has it that they may be the so-called "nerve gases" whose potentiality for harm brought bad dreams to our intelligence staff at that time. Be that as it may, these products are so toxic that they are limited to applications in the field by trained operators. Their use on livestock and pets is not recommended. (Department of Understatement.)

Physical and Chemical Properties

The organic phosphorus compounds are among the most toxic chemicals used for

pest control. Exposure to relatively small amounts may result in severe illness or death.

TEPP (or tetraethylpyrophosphate) is the most potent of the group from the acute standpoint. It is **several times** more toxic than **nicotine.** HETP (hetraethyl-tetraphosphate) is on a par with nicotine and owes most of its destructive potential to the percentage of TEPP present in the mixture. Both these compounds are rapidly hydrolysed and therefore dangerous for only a few days after application. They are also rapidly detoxified in the body and therefore not stored in the tissues.

Parathion is an ester of thiophosphoric acid and contains a sulfur radical. It is more slowly decomposed and as a result presents more of a hazard. It is also fat soluble to some extent.

Toxicology

There is little difference in susceptibility among various animal species to the toxic effects of these compounds. Several hundred human cases of poisoning have been reported with a number of fatalities—most of them due to carelessness in handling the products.

The organic phosphates are toxic by absorption through the skin, by inhalation and by ingestion. As little as one drop of concentrated solution in the eye has caused death. Whereas TEPP and HETP have failed to show cumulative effects, animal experiments have shown that repeated contact with small amounts of parathion may produce poisoning.

It has been estimated that 25 mg. of TEPP by mouth will produce moderately severe symptoms in man. 100 mg. orally would probably be fatal as would 500 mg. applied to the skin.

The alkyl phosphates inhibit the enzyme cholinesterase. This enzyme destroys acetylcholine, one of the chemicals liberated at nerve junctions and endings to transmit the nerve impulse. Thus a lack of the enzyme results in a marked prolongation of each nerve impulse affecting primarily the parasympathetic part of the nervous system. Nicotine-like effects are also produced.

On acute exposure symptoms develop rapidly once the cholinesterase level has been sufficiently lowered. They include loss of appetite, nausea, vomiting, abdominal cramps, excessive sweating, pupillary constriction, diarrhea, respiratory difficulty, headache, dizziness, muscle twitching and weakness. Severe cases develop coma, convulsions and death.

Repeated exposure to small doses may result in illness of severe degree. The enzyme system recovers fairly rapidly after one episode, but may take weeks after numerous subclinical contacts. Testing a blood sample for cholinesterase levels may help in diagnosis. Sedatives and the hypodermic administration of atropine in doses of 1 to 2 mg. as often as every hour may be life saving in severe cases of poisoning. Death may occur within six to ten hours of the development of symptoms. Recovery from acute attacks is usually complete. Adequate protective clothing and special masks must be used by those handling these chemicals.

TEPP and HETP present no problem. Fruit pickers have become ill after entering an orchard treated with parathion several days after its application. Food crops are not supposed to be sprayed within thirty days of harvest. A safe residue on any one item of diet is considered to be 2 ppm of parathion. In the case of citrus fruit the peel will absorb and retain higher residues than are allowable. This is also true of other fruits. As regards apples and pears, if parathion is applied—"**strictly in accordance with the recommendations** of the Bureau of Entomology & Plant Quarantine of the U. S. Dept. of Agriculture with particular reference to the time between the last spraying and the harvesting of the fruit, normal weathering should result in parathion residue no greater than a fraction of a part per million."

Nevertheless toxic parathion residues have been reported by Pottenger in bread and canned fruit. Again the human equation enters the picture.

Susceptibility to the organic phosphates is variable as one would expect. In cases of suspected poisoning a physician should always be called. Blood tests may uncover chronic cases.

Absorption and Translocation

TEPP is rapidly absorbed into plant tissues as shown by growth inhibition or stimulation and other metabolic disturbances. The rapid breakdown of these compounds limits the importance of their absorption to the effect on plants.

Parathion has been reported to kill a variety of insects on plants when applied only to the soil. Biochemical studies and bioassay have shown that absorption and translocation does take place in insecticidal amounts. The relative stability of this chemical together with its toxicity makes these findings of great importance to animals and humans. Chemically altered parathion has been found in some citrus fruits. The toxicity has not yet been reported.

Systemic Insecticides

These are chemicals absorbed and translocated by actively growing plants in sufficient amounts to kill insects feeding at a site distant from the original application. The principal compounds of this group are "OMPA" (octamethlypyrophos-

phoramide), "Systox" (diethyl ethylmercaptoethyl thiophosphate), triphosphoric acid penta dimethylamide and the bis fluorophosphine oxides.

After absorption the chemicals may be changed to **less** or **more toxic** compounds. Injury to the plant is possible. Translocation to edible portions may make them toxic or produce a tainted flavor. At the present time the use of these systemic pesticides on food crops is not permitted. They are still in the experimental stage and should always remain so as far as food for man or animal is concerned.

It should be stated once more that in addition to the systemics just described, evidence of absorption and translocation exists for arsenical compounds, parathion, benzene hexachloride, DDT, toxaphene, chlordane, dieldrin, selenium compounds, fluoroacetates, and fluorohydrins. The last four groups have been considered too toxic for use on food crops, although dieldrin has recently been released for use on peaches in California. Benzene hexachloride (as reported in Modern Nutrition for October) may no longer be applied to vegetables or fruits in this state. However, where it has been used in the past the soil may remain contaminated to a decreasing extent for five years or more.

It has taken a long time for the authorities to take such a step and now treated ground will not be free from traces of the chemical for eight or ten years more. In the meantime the population has been exposed to the effects of BHC for a period of four or five years. This is but one example of the price the public is paying for the use of new chemicals in and on our food without adequate investigation of possible harmful effects from these poisons.

Practical Aspects

By this time those who have followed these articles should be considerably alarmed over the number of poisons human beings in this atomic age must encounter. And rightly so! It is a deadly and grim situation. Naturally the question now arises—so what? Where do we go from here? What can I do to protect my family, myself and our wonderful Nation from what seems to be serious harm?

Unfortunately there is no pat answer. However, I am going to discuss steps which seem logical at the present time.

Legislative Action

While your government representatives in local, state and federal capacities realize there is a problem and wish to protect the public, they are under pressure from pesticide manufacturers and distributors whose chief interest naturally is in sales. These groups refuse to believe that exposure to small amounts of insecticides constitutes a great threat to public health.

Entomologists being primarily responsible for the production of large crops to feed a hungry world are loth to accept proof of chronic toxicity—and such proof in **humans** is difficult to obtain. (There is plenty of evidence of such potential hazard from animal experiments.) Meanwhile Departments of Agriculture are busy conducting investigations along lines of toxicity for crops, animals and man.

You are the guinea pigs and must write your state and federal representatives asking them to take action. You must also contact your local departments of health along the same lines. The other side of the question must be heard from.

Personal Precautions

In an attempt to avoid contaminated foods one must not go off the deep end and develop malnutrition in the process. Many foods from large truck farms where spraying directions are carefully followed and supervised contain no detectable residues. However, a certain number of crops, because of ignorance, willful neglect of advice, drift from nearby fields or other factors show slight or moderate and occasionally, heavy contamination. Surveys in the Los Angeles area in 1950 showed detectable residues of DDT in more than half the samples examined. About four percent were heavy. Arsenic contamination was negligible This risk is unpredictable and at the present time cannot be prevented. The following suggestions may be helpful:

1. Whenever possible, purchase foods that have been grown without the use of toxic insecticides. At present the supply of such foods is markedly limited. Encourage the development of organic farms in your area. Grow your own vegetables.

2. Do not use sprays or aerosols in your house that contain DDT, Chlordane, lindane, BHC or methoxychlor. Make sure that commercial exterminating companies do not use these chemicals in your house or on your trees and shrubs. Do not eat in restaurants using vaporizers for fly control.

3. Peel all fruits and vegetables that lend themselves to such treatment. Scrape the outside layer from celery. Washing will not remove residues. Purchase eggs from local ranches that are not using DDT, BHC or chlordane in hen houses. (Methoxychlor and lindane are not cumulative and do not ordinarily build up in chicken tissues, hence in eggs.)

Milk, cream and butter are much safer than formerly. Most dairies now use methoxychlor and lindane for fly control and very little is excreted in the milk. Check with your local dairy to find out what chemicals they use. Shift to another dairy if yours is still using DDT, BHC or chlordane or dieldrin by the "strip" method.

Most vegetables growing in the ground such as potatoes, carrots and beets are comparatively safe. Contamination by BHC will produce an off flavor and thus give warning. Potato skins may be eaten.

Fruits and vegetables that have at intervals shown contamination with DDT in the Los Angeles area are celery, cabbage, cauliflower, greens (spinach, parsley, endive, turnip, etc.) and lettuce. Apples and tomatoes are included, but quite safe when peeled. In case of stomach upsets it would be wise to avoid these vegetables for a few weeks.

Dried fruits may be higher in DDT than fresh fruit and they cannot be peeled. Some olives and grapes are suspect. Prunes show very little residue as a result of the alkali treatment given them.

Moderate amounts of salads greens are fairly safe and desirable food stuffs. Home sprouted soy beans, mung beans, watercress and the like from untreated seeds provide an excellent source of uncontaminated and nutritious salads.

Lean meats are satisfactory sources of protein and sea foods are naturally free of any residues.

4. Attention to other factors affecting the general health is important. Adequate rest, avoidance of worry and tension, moderation in the use of coffee, alcohol and tobacco, sufficient exercise and a diet low in refined carbohydrates need emphasis. Vitamin supplements such as yeast or vegex, dessicated liver, rice bran concentrates, fresh wheat germ, cod liver oil or its concentrates and kelp for trace minerals are helpful. More potent preparations are often indicated but should preferably be taken only under medical supervision.

Allergic states and chronic infection of any sort interfere with adequate metaboiism and should be corrected if possible. Naturally other ailments should receive the necessary care.

5. Repeated attacks consisting of upper respiratory infections and/or gastrointestinal symptoms together with loss of weight and marked fatigue suggest pesticide toxicity or allergy. In any case of this sort see your physician. Other causes may be operative. If he finds nothing wrong suggest the possibility of insecticide poisoning and ask for a blood count and liver function tests. Do not try to diagnose and treat yourself. You are almost bound to be mistaken and to do more harm than good.

In definite cases of DDT poisoning a strict diet together with other nutritional therapy will be necessary. Recovery is often discouragingly slow but sure once the cause has been recognized.

Summary and Conclusions

The various types of chemicals used for the control of insect pests have been described together with their potential toxicity for man and animals. The fact that some of the chlorinated hydrocarons, even when absorbed in trace amounts, may be concentrated at least thirty fold in the body fat of animals and human beings, renders even slight contamination of our foods a public health problem, of first importance. Such contamination **is present** and in susceptible individuals **is producing illness.** This fact must be faced and steps taken to protect the public interest. The Delaney Congressional Committee has been investigating the problem and will recommend legislation if this seems needed. The Committee needs the support of all.

Suggestions have been made by means of which the public may reduce the intake of insecticides to a minimum. It is impossible to avoid all contact.

If the use of insecticides were suddenly stopped crop failure and hunger would be widespread. Perhaps the solution may lie in the following steps:

(1) Fairly rapid abandonment of the more toxic pesticides in favor of less harmful ones.

(2) The development of widespread pest control by natural enemies. Excellent research on this subject is being carried on at the Riverside Experimental Station.

(3) As Pottenger has suggested, foods that have been sprayed or dusted should be so labelled including the insecticides used. The public has the right to know what it is buying.

(4) Testing of food crops before marketing. While costly it might be cheaper in the end, to test for BHC, DDT, arsenic, lead and parathion, where any or all of these have been used on food crops **before the crop is sent to market.** To allow for differences in concentration and other factors, a sample from each acre might be indicated. Thus heavily contaminated crops would be discovered before reaching the consumer.

(5) The passage of State or National laws condemning the manufacture of aerosols, sprays or vaporizers containing DDT, chlordane ,lindane or methoxychlor for use in homes or public places. These chemicals should be used only outdoors and then with extreme caution.

(6) The gradual spread of organic farming methods including the use of city wastes for fertilizer purposes. The work of E. Pfeiffer along the lines of special cultures to produce a rapid breakdown of organic material shows much promise. In spite of a great deal of skepticism, an increasing number of farmers and soil experts believe that healthy plants are more

resistant to insect pests and that healthy plants can only grow in rich soil. It is probable that the future of America and, indeed of the world, depends upon the rebuilding of our impoverished soil through the addition of organic matter, trace minerals and judiciously used commercial fertilizer—not upon the development of newer and more powerful insecticides.

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