Opponents Call It Danger to Environment; Killer of Many Life Forms

By Dr. CHARLES WURSTER, JR.

Dr. Wurster is assistant professor of biological sciences at State University of New York at Stony Brook. He was recommended by the office of Sen. Gaylord Nelson as one of the leading authorities on DDT.

DURING the past quarter-century, man has subjected his environment to an increasing variety of chemical insults in the form of pollutants with molecular structures never before encountered by living organisms. Of these contaminants, the chlorinated hydrocarbon insecticides (those, such as DDT, that contain chlorine, carbon, and hydrogen) are probably more widely distributed than any other synthetic chemicals and have become one of the world's most serious pollution problems.

Residues of DDT and some of its relatives seem to be almost everywhere—in soils never treated with the chemicals, in birds and seals that never leave the Antarctic (although DDT has never been used on that continent), in most other animals and probably all humans, in the air, even in remote parts of the world, and even in the rain. Yet, after 25 years of use, the physiological mechanism of action for the chlorinated hydrocarbons is poorly understood, and we are only now discovering some of its environmental effects. We are, in a sense, conducting a biological experiment of colossal proportions, using the entire world as a laboratory.

How will it all come out? No one knows. Clearly some parts of the experiment have gone sour, and the flow of bad news increases as the data come in. Not all is mystery about these chemicals, however, for there is a great deal we do know about them.

DDT was first made in 1874, but its insecticidal properties were not discovered until World War II. With a high toxicity, great persistence, and side effects that were neither of concern nor well understood at the time, DDT was the miracle insecticide that played a heroic and glamorous role in the war, saving thousands of lives that would otherwise have been lost to malaria, typhus, and other insect-borne diseases. After the war it became a panacea for all insect problems, and its usage was greatly expanded.

While DDT has been the most widely used and extensively studied, and its residues are the most widespread within the environment, most other chlorinated hydrocarbons have similar properties and should be expected to have comparable ecological effects. These include dieldrin, aldrin, endrin, heptachlor, chlordane, lindane, and others commonly used against insects under a host of circumstances, including gardens, farms, and forests.

Properties Cause Unique Problems

In order to understand the movement and consequences of these materials within the natural environment, it is first necessary to know something of their properties. The chlorinated hydrocarbons present a relatively unique environmental problem because they combine four important characteristics in the same molecule:

1 Broad Toxicity and Biological Activity—Rather than having a toxic action that is limited to insects, as is popularly supposed, the chlorinated hydrocarbons are toxic to a broad spectrum of living organisms, including most of the animal kingdom and all vertebrates. All are nerve poisons. They cause instability or spontaneous "firing" of nerve cells, and increased doses result in tremors or convulsions—typical symptoms of acute poisoning that can occur in organisms ranging from houseflies to man. In general, if an organism has nerves, the chlorinated hydrocarbons can kill it.

Recent studies have uncovered other, more subtle, yet probably more important, mechanisms of action. At sublethal concentrations, organisms show increased nervousness, hyperactivity, and various behavioral abnormalities. We now know that most chlorinated hydrocarbons are enzyme inducers, i.e., they can induce enzymes in the liver that modify the steroid sex hormones, thus changing their biological activity and affecting vital physiological processes. At the same time, some members of the DDT family can function as estrogens, thus perhaps further upsetting hormone balance. Very recent work now suggests that DDT may inhibit carbohydrate metabolism, that it may affect the genetic material to influence future generations, and that it may be carcinogenic; each of these mechanisms needs further research.

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Defenders Say Environment —And Especially People— Endangered Without It

A BILL has been introduced before Congress to ban the nationwide sale of DDT.

Sen. Gaylord Nelson of Wisconsin has forced upon our elected representatives the necessity of making a decision.

They must decide who shall have priority of protection—people, or certain birds and fish.

The decision should be easy.

There is even a question of whether defeat of the bill would mean defeat (much less doomsday) for the birds and fish. There is strong evidence, however, that banning DDT could eventually impose death or a life sentence of misery upon literally thousands of people around the world.

Lawmakers will be weighing the merits of the case against DDT with the findings of a recently completed 18-month study conducted at the request of the U.S. Department of Agriculture.

Fifteen scientists of the National Academy of Sciences and National Research Council heard 83 principal witnesses. These spokesmen included authorities from scientific and conservation organizations, industry, universities and government agencies.

A full report of their study may be obtained from Press Service, Office of Information, USDA, Washington, D.C. 20250. A summary of the committee's conclusions and recommendations follows:

Conclusions

1. Persistent pesticides are contributing to the health, food supply, and comfort of mankind, but, in the absence of adequate information on their behavior in nature, prudence dictates that such long-lived chemicals should not be needlessly released into the biosphere.

2. Although persistent pesticides have been replaced in some uses and are replaceable in others, they are at present essential in certain situations.

3. No decrease in the use of pesticides is expected in the foreseeable future. On a world basis, increased use is probable.

4. Although the use of DDT has decreased substantially, there was no important change in the use of other organochlorine insecticides in the United States during the 10-year period ending June 30, 1967.

5. Available evidence does not indicate that present levels of pesticide residues in man's food and environment produce an adverse effect on his health.

6. Registration requirements for persistent pesticides appear to provide adequate safeguards for human health, but continuing attention must be given to accommodating new knowledge and insuring against subtle long-term effects.

7. Residues of certain persistent pesticides in the environment have an adverse effect on some species of wild animals and threaten the existence of others.

8. The availability and low cost of effective persistent pesticides have slowed the development and adoption of alternative methods of control.

9. Work on nonchemical methods as alternatives to persistent pesticides has been emphasized in recent years, and continued support for this work is needed.

10. Inadequate attention and support are being given to developing pesticidal chemicals and to improving techniques for using them.

11. Persistent pesticides are of special concern when their residues possess—in addition to persistence—toxicity, mobility in the environment, and a tendency for storage in the biota.

12. A few organochlorine insecticides and their metabolites have become widely distributed in the biosphere, appearing in the biota at points far from their places of application.

13. The biosphere has a large capacity for storage of persistent pesticides in the soil, water, air, and biota, but little is known concerning amounts of persistent pesticides and of their degradation products that are stored in the biosphere.

14. Knowledge is incomplete concerning the fate and degradation of persistent pesticides in the environment, their behavior in the environment, the toxicity of the degradation products, and the interaction of these products with other chemicals.

15. Present methods of regulating the marketing and use of persistent pesticides appear to accomplish the objectives of providing the user with a properly labeled product and holding the amounts of residue in man and his food at a low level. However, they do not appear to insure the prevention of environmen-

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DDT Is 'Compound of Extinction'

Falcon, Eagle Decline Blamed on Variation of DD

DDT Harm to Trout Claimed

UW Wildlife Expert Links DDT With Decline of Birds

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2 Mobility—Unfortunately, these insecticides do not remain where they are applied, dispersal through the environment being facilitated by a variety of transport mechanisms. Obviously the chemicals can travel about within living, mobile organisms, though this mode of transport seems minor. Despite low water solubilities and vapor pressures, large amounts can be carried by vast quantities of moving water and air, and dispersal is further facilitated by the tendency of these materials to form suspensions in both air and water. Since many insecticide application procedures intentionally produce atomized droplets or particles, substantial amounts are thereby passed into the atmosphere. Less than half the amount sprayed from a plane may reach the ground. Once in the air, these materials can circle the globe in a few weeks; fallout from the air probably contributes about the same quantity of pesticides to the oceans as do major river systems.

The chlorinated hydrocarbons also readily adsorb to particulate matter like soil particles, which are carried away by wind and water. Escape into the air is further aided by the process of codistillation, whereby the chemicals pass into the vapor state associated with evaporating water. Thus a wet field will release pesticides into the air much more rapidly than will a dry one. It is clear, then, that these insecticides can be transported about much of the earth to points far distant from the original application site by currents of water and air, as well as by mobile organisms.

3 Chemical Stability—In the environment, the chlorinated hydrocarbons are very stable compounds; they probably have a half-life of many years or decades, but exactly how long they persist we do not know. Mechanisms for effectively metabolizing or breaking down these exotic materials apparently have not evolved, although certain tissues, particularly liver, can bring about gradual breakdown. DDT is slowly metabolized into DDE, DDD, and eventually other compounds, but unfortunately most of these, too, are toxic and induce liver enzymes. DDE, apparently more stable than DDT, is probably the world's most widely distributed synthetic organic chemical.

Treated areas show declining residues during subsequent years, but this "disappearance" is sometimes falsely equated with decomposition. The two are not the same. Increasing evidence indicates that much of these materials have simply gone elsewhere in their original, or slightly modified, form, retaining their biological activity.

4 Solubility Characteristics—DDT is insoluble in water—almost. DDT saturates water at only 1.2 parts per billion (ppb), making it one of the most insoluble organic substances known. Conversely, the chlorinated hydrocarbons are soluble in lipids (fats or fat-like materials). They are, therefore, invariably more soluble in any biological material, living or dead, than in water, since all organisms contain lipids. If we divide the biosphere into the inorganic (nonbiological) and the organic (biological), we must always expect the chlorinated hydrocarbons to flow from the former into the latter. Organisms, therefore, remove these chemicals from their environment and retain them.

DDT Travels Far

These four properties mean that biologically potent chemicals will contaminate non-target organisms far removed by both time and space from the site of application.

Chlorinated hydrocarbons may be absorbed by organisms through the gills, the skin, from the diet, and from the air via the lungs. Muds and other solids that hold these chemicals by absorption serve as reservoirs, feeding the chemicals into the water as they are absorbed by organisms. Living organisms accumulate these residues and become contaminated, often from an environment that may appear relatively "clean." For this reason some measurements of environmental quality are misleading. One must analyze living organisms, rather than water, to monitor water quality. Water and air are the transport media, but they contain only minute amounts of these chemicals.

Biological Concentration Occurs

Once these insecticides get into food chains, something else happens—the phenomenon of biological concentration, often called biological "magnification." Each organism eats many organisms from the next lower trophic level, i.e., the next step down in the food chain. A robin, for example, eats many earthworms, and a large fish eats many smaller fish. These food organisms are digested and excreted, but the chlorinated hydrocarbons are retained. The chemicals remain in biological material and therefore accumulate, the concentration depending on rates of intake, breakdown, and excretion.

The use of DDT in attempted control of Dutch elm disease is a clear and relatively simple example of food chain contamination. Since DDT is sprayed when the elms are leafless, only a small fraction remains on the trees. The rest is either lost into the air or settles to the earth. That retained by the tree eventually also reaches the ground. Earthworms and other organisms that work the soil accumulate the DDT and become contaminated. Many species of ground-feeding birds eat the soil organisms, concentrate the DDT further, receive a lethal dose, and die with tremors.

Flying insects also become contaminated by contact with the trees and soil, especially those emerging from soil dwelling larvae. Insectivorous birds of the treetops thereby also become involved in this mass avian mortality. In some treated areas, robin mortality has been virtually complete and birds of all species have been reduced by as much as 90 percent.

Wide areas of the coniferous for-

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Hearings In Spotlight

The Case for DDT

California Scientist Gives Warning

Up With People

And Down With the Venomous Foes of Chemical Pesticides

Scientist Testifies

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tal contamination.

16. Public demand for attractiveness in fruit and vegetables, and statutory limits on the presence of insect parts in processed foods, have invited excessive use of pesticides.

17. The National Pesticide Monitoring Program provides adequate information about residues in man and his food, but it does not provide adequate information about the environment generally, because it can detect changes in residues only in selected parts of the biosphere.

18. Contamination of the biosphere resulting from the use of persistent pesticides is an international problem. Changes in techniques for using these pesticides and the substitution of alternatives here and abroad are questions of immediate concern to all mankind.

Recommendations

The Committee recommends—

1. That further and more effective steps be taken to reduce the needless or inadvertent release of persistent pesticides into the environment.

2. That, in the public interest, action be increased at international, national, and local levels to minimize environmental contamination where the use of persistent pesticides remains advisable.

3. That studies of the possible long-term effects of low levels of persistent pesticides on man and other mammals be intensified.

4. That efforts to assess the behavior of persistent pesticides and their ecological implications in the environment be expanded and intensified.

5. That public funds for research on chemical methods of pest control be increased without sacrifice of effort on nonchemical methods.

6. That the present system of regulation, inspection, and monitoring to protect man and his food supply from pesticide contamination be continued.

7. That the objectives and procedures of the National Pesticide Monitoring Program be reviewed and that the feasibility of obtaining data on quantities of persistent pes-

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USDA Pesticide Suspension Order No 'Confession'

USDA's suspension from use of nine pesticides should not be interpreted as an "admission" that these chemicals are harmful to wildlife and people, a Department spokesman told WTT's editor shortly after the announcement was published in mid-July.

One of the pesticides is DDT, which Sen. Gaylord Nelson of Wisconsin is seeking to ban nationwide through a bill now before a congressional subcommittee.

Questioned about the timing and effect of the USDA suspension with regard to this legislation, the spokesman spelled out USDA's position generally on chemical pesticides:

"We are categorically not in favor of any action that represents an across-the-board ban on DDT or any other pesticide. Any action that's taken should be on a case-by-case basis."

The spokesman added that he did not believe the Nelson bill would pass.

The suspension on the use of nine chemicals isn't necessarily permanent, the spokesman pointed out. Rather, it is for the duration of the review, expected to be completed within 30 days.

"Some programs may require a quick decision and be reinstated before 30 days," he said. "On other programs, the review (and suspension) may need to be extended."

The review was initiated, the spokesman explained, just to "show response to the NAS (National Academy of Sciences) study and recommendations and the request of wildlife conservationists."

A report by NAS and the National Research Council had recommended that "further and more effective steps be taken to reduce the needless or inadvertent release of persistent pesticides into the environment."

The spokesman said the review is to see if in fact there are more effective steps that could be taken on those programs carried out by USDA.

"Basically, we'll be looking for effective alternatives," he said, since, repeating the words of the release, "USDA programs in the past have been carefully planned and carried out to insure maximum safety to man, animals and our natural resources."

It is the Department's intention, he said, to carry out the review so that it "won't unduly delay" critical programs.

The suspension order affects programs of the Agricultural Research Service and the Forest Service involving any planned applications of DDT, dieldrin, endrin, aldrin, chlordane, toxaphene, lindane, heptachlor, or BHC.

Bills Ask DDT Ban; Pesticide Commission

Summaries of Wisconsin Senator Gaylord Nelson's two bills affecting DDT follow.

Bill 1753 would amend the Federal Insecticide, Fungicide and Rodenticide Act by adding Sec. 17. The paragraph would make it unlawful for any person to distribute, sell, or offer to sell, DDT in the U.S. after June 30, 1970. It also would be unlawful to receive DDT from any foreign country.

Bill 1799 would establish a National Pesticide Commission. Under provisions of this bill, the President would appoint three representatives from government agencies, three from the scientific and medical professions, two each from conservation and agricultural organizations and two from private enterprises for a term of three years.

The commission would be responsible for:

1. Determining and evaluating the present usage of pesticides;

2. Reviewing existing limitations on pesticide use and

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current labeling requirements;

3. Recommending standards of safety for pesticides in water;

4. Developing a continuing monitoring program for pesticides in the soil, air, water, wildlife, fish and humans;

5. Fostering research in the development of less persistent, less toxic pesticides;

6. Initiating basic research into the degradability of pesticides;

7. Conducting research on the effects of pesticides on the environment, fish and wildlife and humans; and

8. Making recommendations on the elimination or limitation of use of certain pesticides to the President and Congress.

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ticides in the biosphere be studied.

No Danger to Humans

The strange aspect of the DDT controversy is that the cry for a total ban on usage comes at best on the basis of questionable evidence of damage to wildlife. And this absolute position is taken without apparent regard for the consequences that people would suffer.

Evidence to the contrary is too strong for opponents to contend that DDT is a threat to human life.

The summary of a study conducted by the National Communicable Disease Center at Atlanta, Ga., states:

"A study was made of 35 men with 11 to 19 years of exposure in a plant that has produced DDT continuously and exclusively since 1947.

"Findings from medical history, physical examination, routine clinical laboratory tests, and chest X-ray attributable to exposure to DDT. film did not reveal any ill effects It was estimated that the average daily intake of DDT by the 20 men with high occupational exposure was 17.5 mg per man per day as compared to an average of 0.04 mg per man per day for the general population."

Dr. Thomas H. Jukes, a biochemist at the Space Sciences Laboratory at the University of California, described recently the greatest "experiment" with DDT. It took place in India with American assistance. It began in 1953 and was stepped up in 1958.

The success of the program "depended upon the fact that DDT is a residual insecticide," said Dr. Jukes.

"At the start, there were 75 million cases of malaria in India, and life expectancy for Indians was 32 years. By 1962, 147,593,270 pounds of DDT had been used, and life expectancy had jumped to 47 years. By 1967, there were fewer than 100,000 cases of malaria in India.

"DDT is safe, and has been studied more than any other pesticide for its effects on human beings," Dr. Jukes said.

"Without pesticides, there wouldn't be enough food to go around. Most important DDT is needed by the millions of people because it is a cheap, safe residual pesticide."

At one time malaria killed two million people and left millions of others debilitated from the disease each year, another biochemist testified recently.

Ban would Be 'Disastrous'

Dr. Wayland J. Hayes, former Chief of Toxicology for the U.S. Public Health Service and now a professor at Vanderbilt University, Nashville, Tenn., said that while malaria isn't a threat to public health any longer in the U.S., it remains a major killer of people in many parts of the world.

"DDT still remains the most important single tool for control of malaria," he said.

A ban on DDT would prove "disastrous," as undoubtedly there would be a resurgence of malaria without it.

There would be a particularly adverse effect on the control of malaria in emerging nations which look to the U.S. for leadership.

Dr. Hayes said he feared people in other countries would feel that if DDT were banned in the U.S., it would not be safe for use in their countries, and that many human lives would be needlessly lost.

Dr. Jukes, agreeing, cited an article that predicted the campaign against pesticides could cause deaths and sufferings greater than those of World War II.

DDT Does Break Down

Dr. Hayes testified at public hearings on a proposal to impose a state ban on DDT in Wisconsin. Other witnesses questioned the very basis of Dr. Wurster's position against DDT that it is permanently stored and that the buildup is now endangering certain species of wildlife.

"I know of no natural situation where DDT is not degraded," stated Dr. Paul E. Porter, an associate member and consultant to pesticide commissions of the International Union of Pure and Applied Chemistry.

In addition, Porter said DDT does

not build up in plant life, soil water, fish, or mammals, beyond a naturally reversible plateau. When this level is reached, he said, it remains balanced between intake and dissipation.

Porter said DDT is broken down by nature in soil and degraded to far less toxic compounds by the action of micro-organisms present. On vegetation, it is broken down by sunlight and is additionally dispersed by rain and evaporation.

Since DDT adheres to soil particles it is not readily moved by water, making the compound relatively stable, he advised. However, what remains of DDT and its metabolites disappears at an approximate rate of 20% per year, regardless of concentration.

In streams, lakes, and ocean waters, DDT and its metabolite DDE are absorbed on matter which is present, with a considerable portion sinking to muddy water beds.

In mammals and birds, studies reported degradation of DDT through internal chemical action and excretion. A portion of the chemical components are stored in fat, but here again a stored level is reached, Porter testified, with no additional buildup of DDT residues in the animal.

Abnormally high levels of DDT residue reportedly found in many wildlife species may have been inaccurately measured and exaggerated, said Francis B. Coon, chief of the Wisconsin Alumni Research Foundation's chemical department.

"PCBs," polychlorinated biphenyls, Coon pointed out, are compounds that produce an almost identical picture to DDT when analyzed on a gas-chromatograph, an analytical instrument which "fingerprints" chemical compounds.

Until this confusion between DDT and PCBs was recently discovered, most gas chromatographic assays overstated the amount of DDT above that actually in the sample, due to the presence of the PCBs.

Birds Not Affected

DDT-fed pheasants, testified Dr. Frank Cherms, University of Wisconsin professor of poultry science, have exhibited no changes in reproduction rates.

In other tests, turkey and quail were fed 200 parts per million of DDT. The pesticide intake, Cherms said, resulted in no changes in the thickness of egg shells.

Many other factors found in the environment, he continued, could affect differences in shell thickness of wild bird eggs. If birds are frightened, by being chased, or disturbed by cars, dogs barking, horns, or jet airplane sonic booms, thinner egg shells can be the result.

In any experiments in wild birds to ascertain causes of shell alterations, it would be necessary to negate other genetic, disease, and environmental factors before DDT could be ruled the cause of egg failures, Dr. Cherms testified.

In denying that DDT is a threat to wildlife, William F. Gusey, wildlife specialist, noted that "the mammal population on a country-wide basis is in a 'sound state,' and thrifty; big game has increased in numbers for the past 30 years; and population of small game and upland game birds has been quite favorably maintained—as well as many song birds, including robins."

Gusey is a former assistant division chief of the U.S. Department of Interior's Bureau of Sport Fisheries and wildlife.

Dr. Jukes, the California biochemist, strengthens the "sound-state" appraisal of the bird populations by citing a comparison of Audubon Society Christmas bird counts for 1941 and 1960, before and after the widespread use of DDT.

"The greatest increases are in grackles, redwing blackbirds, cowbirds, starlings and robins—up 11-fold to 131-fold.

"I think by far the greatest effect of DDT on birds is to kill mosquitoes that carry serious diseases of wild birds, including malaria, Newcastle disease, fowl pox and encephalitis."

Ban Too Drastic

Banning DDT could bring many lesser adverse effects upon people, not the least of which include predictions that food prices would rise and many more Dutch elm diseased trees would fall, because substitute chemicals are more costly and less effective.

It is vital to realize that DDT still is an essential chemical for which there is no comparable substitute for certain afflictions.

American technology inevitably will solve the problem to the satisfaction of all of us. But to impose an outright ban on DDT at this time would be far more serious than to have outlawed the horse as a mode of transportation before the automobile was invented.

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ests of North America have been sprayed with DDT during the past decade to control the spruce budworm. In New Brunswick, Canada, where excellent salmon streams include the Miramichi River, DDT applications have caused severe and widespread losses of salmon, trout, and other fish. After an application of DDT in 1954, not a single salmon fry was seen that year. Harmful effects extended 30 or more miles below the spray zones and lasted for several years. And effects were not limited to fish. A single treatment changed the insect ecology of the area for at least three to four years.

Concentrations Eventually Kill

Since the chlorinated hydrocarbons are concentrated as they ascend the food chain, carnivorous birds at the top of this pyramid reach the highest concentrations and face special problems. Death sometimes occurs.

In North America, reproductive success of the osprey has declined sharply. A colony in Connecticut, its habitat and other factors apparently unchanged, declined from 200 pairs in 1938 to 12 pairs in 1965. Their eggs contained 5.1 parts per million (ppm) of DDT residues and productivity was 0.5 young per nest, while Maryland birds with 3.0 ppm produced 1.1 young per nest and normal productivity was 2.2 to 2.5 per nest. Ospreys are fish-hawks and DDT residues in the fish eaten by Connecticut ospreys proved to be five to ten times higher than in the food of the Maryland birds.

Studies of the peregrine falcon in Europe reveal a widespread and rapid population decline which began during the early 1950's. The decline was characterized by egg breakage and egg eating by parent birds, abandonment of nests, and other abnormal breeding behavior, and it coincided geographically and in time with the use of chlorinated hydrocarbon insecticides. Tissues and eggs of the peregrine contained DDE, dieldrin, and heptachlor epoxide.

A highly significant, sudden, and widespread decrease in eggshell thickness and calcium content occurred during 1946-48 in several British birds of prey, including the peregrine falcon. Shell thickness and calcium content were stable from 1900 to 1946, then declined by 7 to 25 percent within a few years with no subsequent recovery. The years of decline coincided exactly with the introduction of DDT into the world environment.

DDT Biological Makeup

But what do eggshells have to do with DDT and reproduction? Quite a lot. In birds, increased absorption of calcium from the diet, decreased excretion, and deposition of calcium in bone marrow are all mediated by estrogen, a steroid sex hormone. The calcium in the marrow is later transported to the oviduct where it becomes part of the eggshell. A subnormal estrogen level interrupts this crucial chain of events in the reproductive cycle.

Recent studies showed that DDT, DDE, and dieldrin induced liver enzymes to break down steroid sex hormones in pigeons, and caused mallards and sparrow hawks to lay thin-shelled eggs and have a lower reproductive success.

In aquatic environments, the chlorinated hydrocarbons may contaminate virtually all organisms at all levels of the food pyramid. This has happened to the Lake Michigan ecosystem. DDT residues in bottom muds averaged 0.014 ppm, but amphipods contained 0.41 ppm, nearly 30 times that of the mud. Several species of fish carried residues 10 times higher than the amphipods, and herring gulls at 99 ppm were 20 to 30 times more than the fish. The gulls showed low breeding success and behavioral abnormalities, and could not withstand stress. When starved, the birds developed tremors and died of DDT poisoning while less contaminated gulls easily withstood the same treatment. (Starvation depletes fat reserves that store DDT residues, thus releasing the toxins into vital tissues.)

Fish Accumulate Residues

The Coho salmon, being a top carnivore, also accumulated residues in Lake Michigan and these were passed into the eggs. Recently almost 700,000 salmon fry died shortly after hatching. The fry were poisoned by residues in the egg yolk during final absorption of the yolk sac. Heavy mortality of trout fry occurred similarly in several New York lakes. For several years, mortality of fry from Lake George was 100 percent.

Clear Lake, California, offers another classic example of biological concentration in action. Additions of DDT to the war in an attempt to control gnats, the last in 1957, were followed by the dying of western grebes, reduction of the nesting colony from 1,000 to 30 pairs by 1960, complete nesting failure among survivors for several years, and 500 to 1,500 ppm of DDD in grebe fat. In 1967, ten years after the last treatment, the grebes still averaged 544 ppm of DDD in their fat, and the colony of 165 pairs still had very poor nesting success.

Effects are by no means limited to the top of the food pyramid. A few ppm of DDT in the water can decrease photosynthesis in marine phytoplankton. These single-celled algae are the indispensible base of marine food chains and are responsible for more than half of the world's photosynthesis. Interference with this process could have profound worldwide biological implications.

The nature and movement of the chlorinated hydrocarbons indicate that they will be transferred from the earth's treated land areas to its ocean basins, where they will accumulate. Being so insoluble in water, however, we cannot expect them to "get lost" in the oceans; they will be picked up by its living organisms. Recent analyses of fish and birds from both the Atlantic and Pacific Oceans indicate that this process is occurring.

The Bermuda petrel is a rare oceanic bird of the North Atlantic that has no contact with any continent or area treated with insecticides. Yet its eggs and chicks average 6.4 ppm of DDT residues, and reproductive success has declined significantly since 1958. Only from its oceanic food chain could this bird become so contaminated.

There are more data from the Pacific, but the story is the same.

Clearly the chlorinated hydrocarbon insecticides cannot continue to be used in the natural environment without serious degradation of the world ecosystem. Fortunately we have a choice. Many biological techniques exist for controlling insect populations, and numerous other less stable, more specific insecticides are available. These alternatives are highly effective. Man's control of pests requires ecological sanity. Which way will we go?