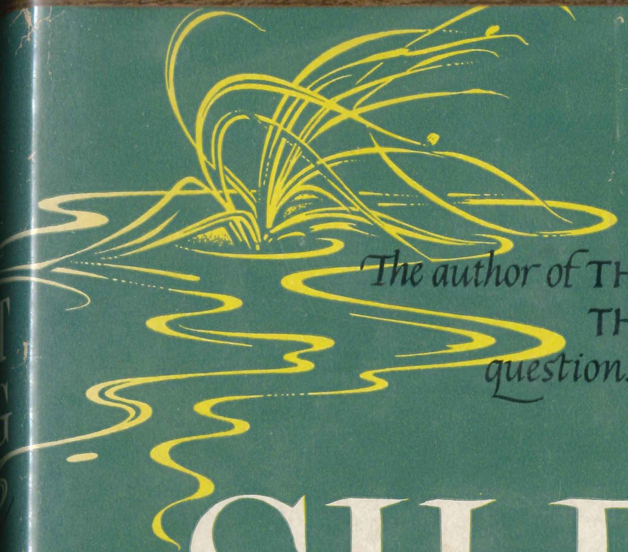

The author of THE SEA AROUND US *and*
THE EDGE OF THE SEA
questions our attempt to control the natural world about us

SILENT SPRING

Rachel Carson

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Rachel Carson

For as long as man has dwelt on this planet, spring has been the season of rebirth, and the singing of birds. Now in some parts of America spring is strangely silent, for many of the birds are dead — incidental victims of our reckless attempt to control our environment by the use of chemicals that poison not only the insects against which they are directed but the birds in the air, the fish in the rivers, the earth which supplies our food, and, inevitably (to what degree is still unknown), man himself.

Rachel Carson, author of *The Sea Around Us* and *The Edge of the Sea,* is a biologist who became so concerned with this situation that she spent four and one half years gathering data from all over America, and from other parts of the world, on the effects of the pesticides now in general use. The facts, as set forth in this book, are appalling.

In terms that any layman can understand, Miss Carson explains what is meant by the "balance of nature." She shows how careful we must be, with the gre[illegible] at our command, not to distur[illegible]

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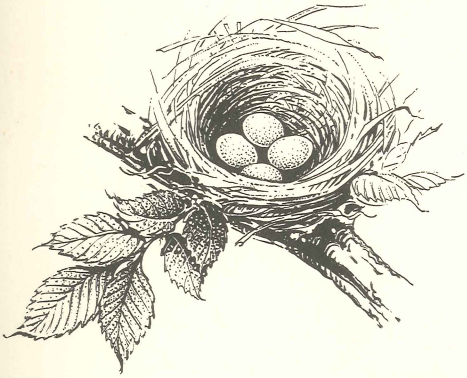
Silent Spring



by Rachel Carson

Drawings by Lois and Louis Darling

HOUGHTON MIFFLIN COMPANY BOSTON
The Riverside Press Cambridge
1962

FIRST PRINTING

PORTIONS OF THIS BOOK WERE FIRST PUBLISHED AS
A SERIES OF ARTICLES IN
The New Yorker

LIBRARY OF CONGRESS CATALOG CARD
NUMBER: 60–5148

The Riverside Press
CAMBRIDGE • MASSACHUSETTS
PRINTED IN THE U.S.A.

as we shall presently see, that the method of massive chemical control has had only limited success, and also threatens to worsen the very conditions it is intended to curb.

Under primitive agricultural conditions the farmer had few insect problems. These arose with the intensification of agriculture — the devotion of immense acreages to a single crop. Such a system set the stage for explosive increases in specific insect populations. Single-crop farming does not take advantage of the principles by which nature works; it is agriculture as an engineer might conceive it to be. Nature has introduced great variety into the landscape, but man has displayed a passion for simplifying it. Thus he undoes the built-in checks and balances by which nature holds the species within bounds. One important natural check is a limit on the amount of suitable habitat for each species. Obviously then, an insect that lives on wheat can build up its population to much higher levels on a farm devoted to wheat than on one in which wheat is intermingled with other crops to which the insect is not adapted.

The same thing happens in other situations. A generation or more ago, the towns of large areas of the United States lined their streets with the noble elm tree. Now the beauty they hopefully created is threatened with complete destruction as disease sweeps through the elms, carried by a beetle that would have only limited chance to build up large populations and to spread from tree to tree if the elms were only occasional trees in a richly diversified planting.

Another factor in the modern insect problem is one that must be viewed against a background of geologic and human history: the spreading of thousands of different kinds of organisms from their native homes to invade new territories. This worldwide migration has been studied and graphically described by the British ecologist Charles Elton in his recent book *The Ecology of Invasions*. During the Cretaceous Period, some hundred million years ago, flooding seas cut many land bridges between their advice. We allow the chemical death rain to fall as though there were no alternative, whereas in fact there are many, and our ingenuity could soon discover many more if given opportunity.

Have we fallen into a mesmerized state that makes us accept as inevitable that which is inferior or detrimental, as though having lost the will or the vision to demand that which is good? Such thinking, in the words of the ecologist Paul Shepard, "idealizes life with only its head out of water, inches above the limits of toleration of the corruption of its own environment . . . Why should we tolerate a diet of weak poisons, a home in insipid surroundings, a circle of acquaintances who are not quite our enemies, the noise of motors with just enough relief to prevent insanity? Who would want to live in a world which is just not quite fatal?"

Yet such a world is pressed upon us. The crusade to create a chemically sterile, insect-free world seems to have engendered a fanatic zeal on the part of many specialists and most of the so-called control agencies. On every hand there is evidence that those engaged in spraying operations exercise a ruthless power. "The regulatory entomologists . . . function as prosecutor, judge and jury, tax assessor and collector and sheriff to enforce their own orders," said Connecticut entomologist Neely Turner. The most flagrant abuses go unchecked in both state and federal agencies.

It is not my contention that chemical insecticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm. We have subjected enormous numbers of people to contact with these poisons, without their consent and often without their knowledge. If the Bill of Rights contains no guarantee that a citizen shall be secure against lethal poisons distributed either by private individuals or by public officials, it is surely only because our forefathers, despite their considerable wisdom and foresight, could conceive of no such problem.

I contend, furthermore, that we have allowed these chemicals to be used with little or no advance investigation of their effect on soil, water, wildlife, and man himself. Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life.

There is still very limited awareness of the nature of the threat. This is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits. It is also an era dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged. When the public protests, confronted with some obvious evidence of damaging results of pesticide applications, it is fed little tranquilizing pills of half truth. We urgently need an end to these false assurances, to the sugar coating of unpalatable facts. It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wishes to continue on the present road, and it can do so only when in full possession of the facts. In the words of Jean Rostand, "The obligation to endure gives us the right to know."

wild animals so universally that scientists carrying on animal experiments find it almost impossible to locate subjects free from such contamination. They have been found in fish in remote mountain lakes, in earthworms burrowing in soil, in the eggs of birds — and in man himself. For these chemicals are now stored in the bodies of the vast majority of human beings, regardless of age. They occur in the mother's milk, and probably in the tissues of the unborn child.

All this has come about because of the sudden rise and prodigious growth of an industry for the production of man-made or synthetic chemicals with insecticidal properties. This industry is a child of the Second World War. In the course of developing agents of chemical warfare, some of the chemicals created in the laboratory were found to be lethal to insects. The discovery did not come by chance: insects were widely used to test chemicals as agents of death for man.

The result has been a seemingly endless stream of synthetic insecticides. In being man-made — by ingenious laboratory manipulation of the molecules, substituting atoms, altering their arrangement — they differ sharply from the simpler inorganic insecticides of prewar days. These were derived from naturally occurring minerals and plant products — compounds of arsenic, copper, lead, manganese, zinc, and other minerals, pyrethrum from the dried flowers of chrysanthemums, nicotine sulphate from some of the relatives of tobacco, and rotenone from leguminous plants of the East Indies.

What sets the new synthetic insecticides apart is their enormous biological potency. They have immense power not merely to poison but to enter into the most vital processes of the body and change them in sinister and often deadly ways. Thus, as we shall see, they destroy the very enzymes whose function is to protect the body from harm, they block the oxidation processes from which the body receives its energy, they prevent the normal functioning of various organs, and they may initiate in cerknown to have occurred. Yet these fish, too, contained DDT. Had the chemical reached this remote creek by hidden underground streams? Or had it been airborne, drifting down as fallout on the surface of the creek? In still another comparative study, DDT was found in the tissues of fish from a hatchery where the water supply originated in a deep well. Again there was no record of local spraying. The only possible means of contamination seemed to be by means of groundwater.

In the entire water-pollution problem, there is probably nothing more disturbing than the threat of widespread contamination of groundwater. It is not possible to add pesticides to water anywhere without threatening the purity of water everywhere. Seldom if ever does Nature operate in closed and separate compartments, and she has not done so in distributing the earth's water supply. Rain, falling on the land, settles down through pores and cracks in soil and rock, penetrating deeper and deeper until eventually it reaches a zone where all the pores of the rock are filled with water, a dark, subsurface sea, rising under hills, sinking beneath valleys. This groundwater is always on the move, sometimes at a pace so slow that it travels no more than 50 feet a year, sometimes rapidly, by comparison, so that it moves nearly a tenth of a mile in a day. It travels by unseen waterways until here and there it comes to the surface as a spring, or perhaps it is tapped to feed a well. But mostly it contributes to streams and so to rivers. Except for what enters streams directly as rain or surface runoff, all the running water of the earth's surface was at one time groundwater. And so, in a very real and frightening sense, pollution of the groundwater is pollution of water everywhere.

It must have been by such a dark, underground sea that poisonous chemicals traveled from a manufacturing plant in Colorado to a farming district several miles away, there to poison wells, sicken humans and livestock, and damage crops — an extraordinary episode that may easily be only the first of many like it. Its history, in brief, is this. In 1943, the Rocky Mountain Arsenal of the Army Chemical Corps, located near Denver, began to manufacture war materials. Eight years later the facilities of the arsenal were leased to a private oil company for the production of insecticides. Even before the change of operations, however, mysterious reports had begun to come in. Farmers several miles from the plant began to report unexplained sickness among livestock; they complained of extensive crop damage. Foliage turned yellow, plants failed to mature, and many crops were killed outright. There were reports of human illness, thought by some to be related.

The irrigation waters on these farms were derived from shallow wells. When the well waters were examined (in a study in 1959, in which several state and federal agencies participated) they were found to contain an assortment of chemicals. Chlorides, chlorates, salts of phosphonic acid, fluorides, and arsenic had been discharged from the Rocky Mountain Arsenal into holding ponds during the years of its operation. Apparently the groundwater between the arsenal and the farms had become contaminated and it had taken 7 to 8 years for the wastes to travel underground a distance of about 3 miles from the holding ponds to the nearest farm. This seepage had continued to spread and had further contaminated an area of unknown extent. The investigators knew of no way to contain the contamination or halt its advance.

All this was bad enough, but the most mysterious and probably in the long run the most significant feature of the whole episode was the discovery of the weed killer 2,4-D in some of the wells and in the holding ponds of the arsenal. Certainly its presence was enough to account for the damage to crops irrigated with this water. But the mystery lay in the fact that no 2,4-D had been manufactured at the arsenal at any stage of its operations.

predators. Plankton organisms were found to contain about 5 parts per million of the insecticide (about 25 times the maximum concentration ever reached in the water itself); plant-eating fishes had built up accumulations ranging from 40 to 300 parts per million; carnivorous species had stored the most of all. One, a brown bullhead, had the astounding concentration of 2500 parts per million. It was a house-that-Jack-built sequence, in which the large carnivores had eaten the smaller carnivores, that had eaten the herbivores, that had eaten the plankton, that had absorbed the poison from the water.

Even more extraordinary discoveries were made later. No trace of DDD could be found in the water shortly after the last application of the chemical. But the poison had not really left the lake; it had merely gone into the fabric of the life the lake supports. Twenty-three months after the chemical treatment had ceased, the plankton still contained as much as 5.3 parts per million. In that interval of nearly two years, successive crops of plankton had flowered and faded away, but the poison, although no longer present in the water, had somehow passed from generation to generation. And it lived on in the animal life of the lake as well. All fish, birds, and frogs examined a year after the chemical applications had ceased still contained DDD. The amount found in the flesh always exceeded by many times the original concentration in the water. Among these living carriers were fish that had hatched nine months after the last DDD application, grebes, and California gulls that had built up concentrations of more than 2000 parts per million. Meanwhile, the nesting colonies of the grebes dwindled — from more than 1000 pairs before the first insecticide treatment to about 30 pairs in 1960. And even the thirty seem to have nested in vain, for no young grebes have been observed on the lake since the last DDD application.

This whole chain of poisoning, then, seems to rest on a base of minute plants which must have been the original conpredators. Plankton organisms were found to contain about 5 parts per million of the insecticide (about 25 times the maximum concentration ever reached in the water itself); plant-eating fishes had built up accumulations ranging from 40 to 300 parts per million; carnivorous species had stored the most of all. One, a brown bullhead, had the astounding concentration of 2500 parts per million. It was a house-that-Jack-built sequence, in which the large carnivores had eaten the smaller carnivores, that had eaten the herbivores, that had eaten the plankton, that had absorbed the poison from the water.

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This whole chain of poisoning, then, seems to rest on a base of minute plants which must have been the original concentrators. But what of the opposite end of the food chain — the human being who, in probable ignorance of all this sequence of events, has rigged his fishing tackle, caught a string of fish from the waters of Clear Lake, and taken them home to fry for his supper? What could a heavy dose of DDD, or perhaps repeated doses, do to him?

Although the California Department of Public Health professed to see no hazard, nevertheless in 1959 it required that the use of DDD in the lake be stopped. In view of the scientific evidence of the vast biological potency of this chemical, the action seems a minimum safety measure. The physiological effect of DDD is probably unique among insecticides, for it destroys part of the adrenal gland — the cells of the outer layer known as the adrenal cortex, which secretes the hormone cortin. This destructive effect, known since 1948, was at first believed to be confined to dogs, because it was not revealed in such experimental animals as monkeys, rats, or rabbits. It seemed suggestive, however, that DDD produced in dogs a condition very similar to that occurring in man in the presence of Addison's disease. Recent medical research has revealed that DDD does strongly suppress the function of the human adrenal cortex. Its cell-destroying capacity is now clinically utilized in the treatment of a rare type of cancer which develops in the adrenal gland.

The Clear Lake situation brings up a question that the public needs to face: Is it wise or desirable to use substances with such strong effect on physiological processes for the control of insects, especially when the control measures involve introducing the chemical directly into a body of water? The fact that the insecticide was applied in very low concentrations is meaningless, as its explosive progress through the natural food chain in the lake demonstrates. Yet Clear Lake is typical of a large and growing number of situations where solution of an obvious and often trivial problem creates a far more serious but conveniently less tangible one. Here the problem was resolved in favor of those annoyed by gnats, and at the expense of an unstated, and probably not even clearly understood, risk to all who took food or water from the lake.

It is an extraordinary fact that the deliberate introduction of poisons into a reservoir is becoming a fairly common practice. The purpose is usually to promote recreational uses, even though the water must then be treated at some expense to make it fit for its intended use as drinking water. When sportsmen of an area want to "improve" fishing in a reservoir, they prevail on authorities to dump quantities of poison into it to kill the undesired fish, which are then replaced with hatchery fish more suited to the sportsmen's taste. The procedure has a strange, Alice-in-Wonderland quality. The reservoir was created as a public water supply, yet the community, probably unconsulted about the sportsmen's project, is forced either to drink water containing poisonous residues or to pay out tax money for treatment of the water to remove the poisons — treatments that are by no means foolproof.

As ground and surface waters are contaminated with pesticides and other chemicals, there is danger that not only poisonous but also cancer-producing substances are being introduced into public water supplies. Dr. W. C. Hueper of the National Cancer Institute has warned that "the danger of cancer hazards from the consumption of contaminated drinking water will grow considerably within the foreseeable future." And indeed a study made in Holland in the early 1950's provides support for the view that polluted waterways may carry a cancer hazard. Cities receiving their drinking water from rivers had a higher death rate from cancer than did those whose water came from sources presumably less susceptible to pollution such as wells. Arsenic, the environmental substance most clearly established as causing cancer in man, is involved in two historic cases in which polluted water supplies caused widespread occurrence of cancer. In one case the arsenic came from the slag heaps of mining operations, in the other from rock with a high natural content of arsenic. These conditions may easily be duplicated as a result of heavy applications of arsenical insecticides. The soil in such areas becomes poisoned. Rains then carry part of the arsenic into streams, rivers, and reservoirs, as well as into the vast subterranean seas of groundwater.

Here again we are reminded that in nature nothing exists alone. To understand more clearly how the pollution of our world is happening, we must now look at another of the earth's basic resources, the soil.

experiments and even in some field trials, using chemicals incorporated in suitable foods. In a test on an island in the Florida Keys in 1961, a population of flies was nearly wiped out within a period of only five weeks. Repopulation of course followed from nearby islands, but as a pilot project the test was successful. The Department's excitement about the promise of this method is easily understood. In the first place, as we have seen, the housefly has now become virtually uncontrollable by insecticides. A completely new method of control is undoubtedly needed. One of the problems of sterilization by radiation is that this requires not only artificial rearing but the release of sterile males in larger number than are present in the wild population. This could be done with the screw-worm, which is actually not an abundant insect. With the housefly, however, more than doubling the population through releases could be highly objectionable, even though the increase would be only temporary. A chemical sterilant, on the other hand, could be combined with a bait substance and introduced into the natural environment of the fly; insects feeding on it would become sterile and in the course of time the sterile flies would predominate and the insects would breed themselves out of existence.

stop
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The testing of chemicals for a sterilizing effect is much more difficult than the testing of chemical poisons. It takes 30 days to evaluate one chemical — although, of course, a number of tests can be run concurrently. Yet between April 1958 and December 1961 several hundred chemicals were screened at the Orlando laboratory for a possible sterilizing effect. The Department of Agriculture seems happy to have found among these even a handful of chemicals that show promise.

Now other laboratories of the Department are taking up the problem, testing chemicals against stable flies, mosquitoes, boll weevils, and an assortment of fruit flies. All this is presently experimental but in the few years since work began on chemosterilants the project has grown enormously. In theory it has

Field tests are being made in several countries: in France and Germany against larvae of the cabbage butterfly, in Yugoslavia against the fall webworm, in the Soviet Union against a tent caterpillar. In Panama, where tests were begun in 1961, this bacterial insecticide may be the answer to one or more of the serious problems confronting banana growers. There the root borer is a serious pest of the banana, so weakening its roots that the trees are easily toppled by wind. Dieldrin has been the only chemical effective against the borer, but it has now set in motion a chain of disaster. The borers are becoming resistant. The chemical has also destroyed some important insect predators and so has caused an increase in the tortricids — small, stout-bodied moths whose larvae scar the surface of the bananas. There is reason to hope the new microbial insecticide will eliminate both the tortricids and the borers and that it will do so without upsetting natural controls.

In eastern forests of Canada and the United States bacterial insecticides may be one important answer to the problems of such forest insects as the budworms and the gypsy moth. In 1960 both countries began field tests with a commercial preparation of *Bacillus thuringiensis*. Some of the early results have been encouraging. In Vermont, for example, the end results of bacterial control were as good as those obtained with DDT. The main technical problem now is to find a carrying solution that will stick the bacterial spores to the needles of the evergreens. On crops this is not a problem — even a dust can be used. Bacterial insecticides have already been tried on a wide variety of vegetables, especially in California.

Meanwhile, other perhaps less spectacular work is concerned with viruses. Here and there in California fields of young alfalfa are being sprayed with a substance as deadly as any insecticide for the destructive alfalfa caterpillar — a solution containing a virus obtained from the bodies of caterpillars that have died because of infection with this exceedingly virulent disease.

Aldrin
BHC
Chlordane
Dieldrin
Heptachlor

7
10
12
27

Continued from front flap

in a way that will ultimately do us more harm than good. She describes the lethal chemicals that have been invented in the brief period since the Second World War and are being produced in greater strength and variety every year. And she shows that much of this program is self-defeating: the insects, in fact, have the last laugh. While we have been progressively poisoning our own environment, many types of insects — including flies and mosquitoes — have been breeding superior races composed of individuals immune to chemical attack. But there is a positive side to the picture. We are learning more and more about nonchemical control that in the long run will be both safer and more effective than the deadly chemicals with which we are now poisoning our world.

One entire chapter is devoted to a subject of the greatest concern: the possible connection between the widespread use of certain chemicals and the incidence of cancer in man. Another deals with the genetic effects of certain chemicals, paralleling those of radiation.

This book will come as a shock to many readers. To others, *Silent Spring* will be a clarification and a revelation. And to the growing number of informed people who are already deeply disturbed it will be a godsend. They know that the time has come to speak.

Jacket design
and text drawings by
Lois and Louis Darling

Lettering by
Samuel H. Bryant

Reading Rachel Carson's books, one has the feeling that she is forever embarked on a voyage of discovery. As a professional writer she uses words to reveal the poetry — which is to say the essential truth and meaning — at the core of any scientific fact. As a trained scientist she has never lost the poet's sense of wonder.

The interests she was later to combine so successfully were foreshadowed even in early childhood — the desire to write and an abiding love of the world of nature. In college she specialized in English composition, then, coming under the spell of biology, she took her degree in that subject and continued in graduate work at Johns Hopkins University, where she studied genetics and development under H. S. Jennings and worked in the laboratories of geneticist Raymond Pearl. From 1936 until 1952 she was on the staff of the U.S. Fish and Wildlife Service as a biologist and editor. Meanwhile, her own literary career had begun: an article in the *Atlantic* led to her first book, *Under the Sea-Wind* (1941). Ten years later came *The Sea Around Us*. Between one spring tide and the next, she had become world famous. The book was on the best-seller lists for 86 weeks and was eventually translated into 30 languages. Among other honors, Miss Carson was awarded the Gold Medal of the New York Zoological Society, the John Burroughs Medal, the Gold Medal of the Geographical Society of Philadelphia, and the National Book Award for non-fiction. She became a member of the National Institute of Arts and Letters and a Fellow of the Royal Society of Literature. On resigning from government service to give full time to writing she received the Interior Department's Distinguished Service Award. Under a Guggenheim Fellowship she then began studies of offshore life which led to *The Edge of the Sea* in 1955.

Rachel Carson

In all her work Rachel Carson's basic interest has been the relation of life to its environment. Since 1958 she has collected data from scientists all over the world about the dangerous effects of deadly poisons, especially in the form of synthetic insecticides, on the living community. The result is *Silent Spring* — a courageous revelation of the forces that modern man has brought into being in his ruthless war on life, an eloquent protest in behalf of the unity of all nature, a protest in behalf of life.