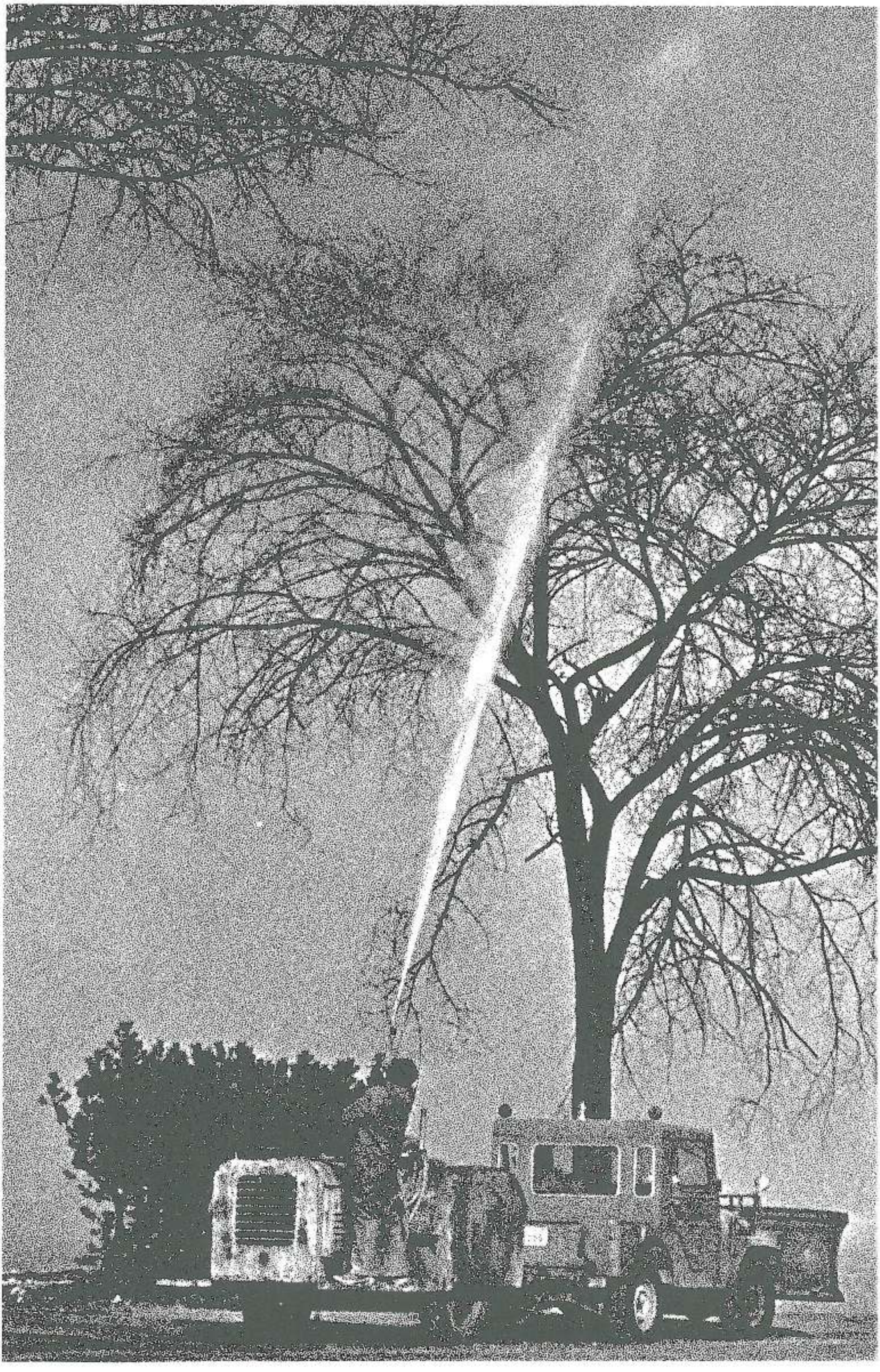

3

Young Man with a Gripe

Q: Dr. Wurster, will you please state your name and residence for the record?

A: Charles F. Wurster, Jr. I live on Crane Neck Road, Oldfield, New York.

Charles Wurster was the hearing's crucial witness, at the same time the strongest and weakest person to take the stand for the petitioners. Although he had appeared in court against DDT in cases on Long Island, in Michigan, and in Milwaukee, and had the reputation for being one of the nation's most knowledgeable experts on *chlorinated hydrocarbon pesticides,* most of his knowledge came from literature-searching. By allowing Wurster to cover the broad spectrum of topics relating to the effects of DDT, Yannacone got a chance to outline what would become his entire case. But, at the same time, Yannacone made his witness an inviting target for industry's attorney, Louis McLean, because Wurster testified, unlike most of the petitioner's other witnesses, outside the realm of his personal scientific experience.

Wurster's testimony did more than set Yannacone's scene. It was directly damaging to DDT's reputation, and not only that, it put down the framework for the interdisciplinary ecological approach to environmental problem solving alien to industry and government but fundamental to the environmentalists in Madison. Wurster attempted to show many, many times during his direct testimony and cross-examination that the old approach to pest control predicated on the insulated work of isolated specialists would not suffice in the pesticide crisis that many scientists envisioned. If Wurster's testimony held up, it would not only succeed in destroying DDT's reputation but would also wreak havoc on the DDT industry's scientific methodology.

Yannacone spent little time in establishing Wurster's credentials, other than getting into the record that he taught at the State University of New York at Stony Brook and that he had personally done research with DDT. McLean broke in to ask what Wurster's doctorate was in and was told, organic chemistry. Then Yannacone started the important questions.

Q: Dr. Wurster, would you summarize for the Hearing Examiner and the record the general properties of DDT, with particular reference to those properties which have given rise to the substance of this particular petition?

A: This is, in effect, the answer to the question, but I would like to start it by describing what I would like to call an ideal insecticide.

Ideally, an insecticide does essentially two things. First, its action is restricted to the target organism, the pest. It doesn't kill other insects. It doesn't damage other organisms that you are not interested in. It does not upset the whole ecological system but rather goes to the heart of the matter, namely, that particular pest, and it kills it or reduces its population to some substantially lower level; but it does not interfere with other systems. And secondly, its action [is] restricted to the place where you put it. It should not be such that it escapes from the site of application and exerts activity elsewhere.

Now this is an ideal insecticide. Unfortunately, we do not have such an insecticide; there is no such ideal insecticide.

There are, however, many insecticides. At this point we have hundreds of insecticides registered. Some of them are better than others. We do have some that have extremely low mammalian or vertebrate toxicity, for example. We have others that are very high. We have some with low stability, some with high stability.

We can, in some ways, rate these [insecticides by] whether they are good or bad . . . according to [the] definition of ideality that I have given.

Unfortunately, the chlorinated hydrocarbons fail completely or virtually completely on both counts [of the definition]. Their activity is not restricted to the pest species.

At this point McLean broke into the examination with the first of his many challenges to Wurster's expertise and credentials.

Q: Pardon me, Doctor. I'm going to object to this answer as being beyond the ken of the witness unless you first qualify him as having some experience in pesticides.

Yannacone then attempted to qualify his witness by a series of questions to Wurster about his experience in the chemical analysis and study of biological effects of DDT, but McLean bore in on Wurster before Yannacone got any further.

Q: Have you—I know of two articles that you have published, one in regard to a robin count and one in regard to DDT in the Bermuda petrel—but I ask if you have written (on the subject of pesticides) any other technical articles describing your studies with them or your evaluation of them.

Wurster answered, yes. Then Yannacone laid a firmer foundation with a question designed to show that Wurster really had a firm grasp of and familiarity with the biological effects of DDT.

Q: Now Doctor, so we get the record developed in order, would you please enumerate for us in your own words—do it any way you wish—what the physical and chemical properties of DDT are that contribute to its biological effect on non-target organisms.

A: In many ways DDT is quite unique. What I will say holds, in part, for a number of other chlorinated hydrocarbons, including *dieldrin, aldrin, endrin, heptachlor* and several others, but I will speak specifically about DDT.

The uniqueness of DDT is caused by the fact that it [shows] a combination of four major factors. If it didn't have each of those four, if it didn't have the combination of all four, then we would have a very different situation than we do. . . .

Q: Doctor, for the record, so that we avoid confusion and objections later on, would you just simply state what the four elements are before explaining them?

A: Number one: [DDT] has broad biological activity that is not restricted to the pest organism.

Number two: It has great chemical stability. It's persistent, in common usage.

Number three: It is surprisingly mobile, . . .

Number four: It has solubility characteristics such that it is relatively insoluble in water and soluble in lipid tissue. . . .

Q: Now, would you start with the first [factor] and explain them in detail?

A: Biological activity: I mentioned [in my definition of the] ideal insecticide . . . that we would like its action to be restricted to the target insect, whatever it happens to be. This, unfortunately with DDT, is not the case. Its activity is very broad. It will kill a variety of beneficial insects. It will kill bees; various predators that may, in fact, be preying on the pest itself. It will, in effect, upset the insect ecology any place that it's put.

Further, its activity is not restricted to insects at all, but includes the entire phylum Arthropoda, arthropods. In other words, it will damage, in one way or another, or kill crustaceans* of various kinds including shrimp, crabs, and lobsters, just to give a few examples.

It also has broad activity through a number of other animal phyla. This would include, for example, such things as annelid worms. It's toxic to annelid worms. Further. . . . it's toxic to fish, birds, mammals, amphibians, and reptiles.

*Crustaceans are a class within the phylum Arthropoda. (Eds.)

Now this biological activity takes many forms. We have spoken so far about [DDT's] tendency to kill an organism, but this is a great oversimplification. It could affect an organism adversely without killing it. . . .

At this point the hearing examiner, Maurice Van Susteren, cut in and tried to figure out exactly what Wurster's specialty was, and was told that, although his degree was in organic chemistry, his work covered a variety of disciplines. This seemed to satisfy Van Susteren, but Louis McLean, the DDT industry's attorney, was not so willing to take Wurster's word.

Mr. McLean: Disciplines, specialities, I don't care how you call it. I have not heard anything yet to qualify him in all these various things. I know very few people—I have never met any person that has all of these specialities, myself.

Mr. Yannacone: You have met one now. You're going to meet a few more during this hearing. . . .

Yannacone continued the examination.

Q: Would you now continue with the discussion of the biological activity of DDT?

A: I had mentioned that we have recently discovered that DDT has *estrogenic* activity, that is, that it does function as a hormone, a female sex hormone. We also know that is does so at incredibly low concentrations. I don't know whether it was mentioned this morning, but hormones function in the parts per billion range and probably lower than that. So it is rather irrelevant to talk about how tiny a part per billion or per million is when these compounds are active at that level. It doesn't matter whether it's a jigger or a drop [of vermouth] in a thousand-tank carload of . . . gin. This is irrelevant. Because we do have extremely sensitive biological systems, we have great biological activity at very low levels.

All right. Now let's go on to the second one of those points: chemical stability.

We all know—I think we know—that DDT is a very stable compound, that it has a *half-life* in the environment circulating in world systems of at least a decade. I think that it's probably a good bit more than that, but unfortunately, we don't really have the data. Nobody has the data.

[In this connection] I will mention a paper by Nash and Woolson which was published in *Science* about 18 months ago. . . .* This was a paper published by some people from the United States

*R. G. Nash and E. A. Woolson, "Persistence of chlorinated hydrocarbon insecticides in soils," *Science*, 157 (1967): 924-927.

Department of Agriculture. [It] shows that 17 years after the application of DDT to a field in Maryland, something like 39% of the DDT was still there. The question of where the rest of it went was not treated in detail. It was hypothesized that some of it probably decomposed. And I'm sure, in fact, some of it did decompose. But where did the rest of it go? We [can't] really know the answer . . . unless we look where we would expect to find it. And that's what I will be getting into.

I do want to point out that analysis of, say, a treated soil or orchard that shows the presence of a residue after a certain number of years does not establish the half-life [of that residue] in the environment. It only establishes the length of time that some of it stayed where you put it. It is not logical—it's completely incorrect—to assume that all of the rest of it broke down, that it went away somewhere, [that] we can forget it. We are now

If DDT were a molecule with a high water solubility, we could afford to have a lot more of it around. We could lose it in those big oceans out there, because it would stay in the water, it would not come out of the water and go into living organisms.
Charles Wurster

learning that we can't forget it; that it goes [elsewhere] and turns up in all kinds of strange places.

All right. How does it get there? Let's go to point three: mobility.

If you look in the chemical and engineering handbook on DDT, [and check] its physical and chemical properties, your initial reaction would be: This is nice stable stuff; if you put it here, it's going to stay . . . and it won't cause any trouble; it won't get spread all over the place. This, it turns out, is altogether incorrect. DDT is much more mobile than we would ever have predicted. Why is this the case? There are a lot of reasons [which] I would like to go through . . . one by one. . . .

Point number one, under this subheading of mobility: DDT does have a water solubility. It's extremely low; it's one of the lowest of any organic chemical known. . . . The best estimate of its solubility is 1.2 parts per billion. . . . But it is not insignificantly low, because there is a fantastic amount of water on this earth. And so, if you have enough leaching, you have enough rain, you have enough water circulating around, water can, in solution, carry levels of DDT that are not insignificant. . . . In other words, even though, at any one time, if you look at water, you find its [DDT content is] either below the limits of detectability or it's virtually absurdly low, . . . there's so much water circulating around that the fact that there is [any] water solubility is a significant factor.

Now as far as transport in water is concerned, you would theoretically, on [the basis of] what I have said, say 1.2 parts per billion is all that water can carry. But this is not correct. Water can carry a good deal more, for two . . . reasons: . . . DDT has a very strong tendency to form *suspensions*. So, rather than being in *solution*, DDT can circulate suspended in water in much larger amounts. . . .

DDT [also] has a tendency to *adsorb* to particulate matter. This means if [DDT] is placed in some soil and then the soil erodes and is carried into streams, rivers, and into lakes, [the water] carries the particulates and the DDT [along with them]. . . .

An example of how dramatic this effect can be was recently shown in California in a paper by Keith and Hunt. . . .* When they took water from a number of locations in California and filtered . . . out the particulate matter, [they found that] the particulates . . . had between 10,000 and 100,000 times the concentration of DDT that was found in the water itself.

So water . . . can carry quite a bit of DDT, most of it not in solution.

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*J. O. Keith and E. G. Hunt, "Levels of insecticide residues in fish and wildlife in California," *Transcript of 31st North American Wild Natural Resources Conference* (March 1966): 150–177.

Now I would like to move on and talk about the air. How does [DDT] get into the air?

. . . DDT does have a finite vapor pressure, [although] it's very low. [DDT is] a relatively nonvolatile material, so you would not expect much loss by volatility. But you do get some loss, because there is some vapor pressure.

But . . . DDT, like its tendency to suspend in the water, also suspends in the air. Most methods of application, at least many methods of application, do their utmost to get the finest particles [possible; in other words,] a spray. The instrument used to spray elm trees usually is a mist blower. This sends a column of mist and very, very tiny droplets up into the air. A good bit of that material will not return to the ground or land on the tree; but the vehicle, the solvent, will evaporate and [leave] tiny crystals. These crystals can be carried into the atmosphere very, very great distances. They can travel, in that sense, all over the world.

Further evidence of this was shown by Dr. George Woodwell a number of years ago in Maine, when he measured the amount of DDT that reached the ground following spraying by an airplane.* When he measured the amount on the ground, he found that it was only half as much, approximately, as was released by the airplane. The rest of it did not reach the ground, but went elsewhere.

Now . . . DDT [as well as adsorbing] to particulate matter and [being] carried by eroded particles into water. . . . is [also] adsorbed to particulate matter that is picked up by the wind and blown as dust around the world. This has been shown in a number of cases. In one of the cases, Dr. Robert Risebrough—sitting over there—found that in association with the dust over the island of Barbados there were dust residues of DDT.†

[It] has been shown, actually, in a number of cases, [that] DDT does adsorb with dust. This means when the wind blows over a treated field, it will pick up some of the material on that field, pick up some of the dust, and the DDT . . . with it.

Now [another] mechanism for movement is one that we have appreciated only rather recently. [It is] the phenomenon of co-distillation. Co-distillation means that when one substance passes into the vapor state, it carries another one along with it. In this case, when water goes into the atmosphere, it carries DDT along. . . .

Actually, this can be dramatically illustrated. Place on the counter here a beaker or glass of water that has suspended in it

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*G. M. Woodwell, "Persistence of DDT in a forest soil," *Forest Science* 7 (1961): 194–196.

†R. W. Risebrough, et al., "Pesticides: Trans-Atlantic movements in the northeast trades," *Science* 159 (1968): 1233–1236.

something in the neighborhood of 10 parts per billion DDT, and let it sit here at room temperature for 24 hours. By this time tomorrow the concentration of DDT in that beaker [will] be roughly half of what it is now; it [will] be down to about five parts per billion. This was shown by workers from the U.S. Department of Agriculture.

And now, finally, there [are] storage mechanisms for [moving DDT] about. It can be transported within the bodies of living organisms that are themselves mobile. This is probably not a major mechanism for transport. [However,] in some cases it's probably important, particularly, for example, in the case of marine birds.

Many of the circulation patterns in the world are east to west patterns, whereas the migration of birds is often north to south. So, . . . if we [consider] some of the very abundant ocean birds like the Wilson's petrel or the shearwater [which] have very long migration routes north to south, . . . they can carry a not insignificant amount of DDT from one pole to the other. Nevertheless, I think this movement within living organisms is a relatively minor point when weighed against the other [points].

So we have, then, eight mechanisms whereby DDT can be distributed about the earth. When put in any one place, it is not going to stay there, but it's going to go to another place. I think it's absolutely essential to realize this point, because it's clear that once [the DDT] molecule is outside, there is no possible way to control it. . . . This means that it doesn't matter who uses DDT, where they use it, how they use it, [or] for what reason. The only thing that matters is whether they use it at all. Once it's outside, all of these mechanisms go into operation, and so the DDT takes off.

My point here is to emphasize that there cannot be the controlled use of an uncontrollable compound. There is no possible way to do it. There is no use in talking about indiscriminate or discriminate use of DDT, or reading the label or not reading the label, or being an expert or not knowing what you are doing. The only thing that matters is whether you use it or not.

Now, at this point, theoretically viewed, DDT is about the earth. This is not just a theoretical idea. Virtually every place we look for DDT, we find it. And if we understand [the] mechanisms [of distribution], it becomes rather clear why we should find it in so many places where we would not originally have expected to find it.

Senator Nelson mentioned yesterday that it's in the penguins in the Antarctic. Well, here's a whole continent where it's never been used. Nobody has ever taken any DDT and lost it in the Antarctic, because the insect population isn't worth bothering about. And yet . . . the penguins, and the fish that the penguins feed on, and the food that the fish eat, . . . all show traces of DDT.

After a brief recess, Wurster continued.

Dr. Wurster: . . . Workers* . . . [have] examined rainwater in Britain, and they also examined the air. . . . In all cases—in virtually all cases—they found residues of DDT present. Further, they examined air over rainwater from a number of cities in Britain, one of them being in extreme northern Scotland. Here's a place [with no] DDT in the immediate vicinity. And yet there was just as much [DDT] there as [in locations directly] to the east . . . that had agricultural areas.

In other words, at this point DDT is part of the normal circulation patterns of the earth. It is not [only] where you put it, but is all over the place, apparently wherever you look for it. Several years ago, some workers in Pittsburgh examined the air over that city and [found DDT] there.† So we have pretty well established that fact that [DDT] is in the air, . . . all the time, wherever you look.

Another example of how this operates is shown in a paper by Cole and Frear and several other authors.‡ [These men analyzed] a forest in Pennsylvania that had never been treated with any

*K. R. Tarrant and J. O'G. Tatton, "Organochlorine pesticides in rainwater in the British Isles," *Nature* 219 (1968): 725–727.

†P. Antomaria, M. Corn, and L. DeMaio, "Airborne particulates in Pittsburgh: Association with *p,p'*—DDT," *Science* 150 (1965): 1476–1477.

‡H. Cole, et al., "DDT levels in fish, streams, stream sediments, and soil before and after DDT aerial spray applications for fall cankerworms in Northern Pennsylvania," *Bulletin of Environmental Contamination and Toxicology* 2 (1967): 127–146.

chlorinated hydrocarbon insecticide. This was essentially a wilderness area that had no farms, no towns, no paved roads, . . . only forest and mountain countryside, and this was quite a substantial area. This area was to be treated with DDT for some insect that had come to the vicinity, [but] before [it was] treated with a chlorinated hydrocarbon insecticide, they analyzed the soil. They found the soil contained five parts per billion dieldrin, four parts per billion *DDE*, and nine parts per billion DDT. So how did it get there? Well, it obviously came down in the rain or came down as fallout or particulate matter.

Furthermore, they analyzed the trout in the streams. Those trout, . . . living in a watershed no part of which had ever been treated, . . . still contained .42 parts per million DDE, .10 parts per million *DDD,* 54 parts per million DDT, and .11 parts per million dieldrin. So . . . four different chlorinated hydrocarbon insecticides [were] present in the trout in those streams in a watershed that had never been treated at all. . . .

Examiner Van Susteren: Just a moment. The watershed had not been treated at all? What do you mean?

Dr. Wurster: [It] had never been sprayed; [they had] never sprayed the veins or any other part of the watershed of that stream. It had never been treated, either [with] DDT or any other chlorinated hydrocarbon. In other words, what was in that watershed, in the soil or in the fish, came down out of the sky.

Examiner Van Susteren: You mean to tell me [that neither] the farmers [nor anyone] else used [DDT] in the entire watershed?

Dr. Wurster: That's right. This is far up in the watershed; this is in the mountains. This isn't the entire river watershed. . . . This was 104,000 acres, . . . which is a pretty large forest.

Further, the suckers in the stream had a good bit higher residues. They had 2.4 parts per million DDE, 3.7 parts per million DDT, and 1.8 parts per million of dieldrin.

Now the water, before they treated this watershed, showed no DDT or any other chlorinated hydrocarbon. Then they began to spray in the vicinity [but] in a different watershed. . . . In other words, for several days they were spraying in surrounding watersheds. And the watershed I'm talking about showed DDT in the water before they began to treat [it].

Have I made that clear?

All right.

Now let me go to item number four.* I have now completed the section on mobility.

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*You will recall that Wurster initially stated that he would discuss four characteristics of DDT: 1) its broad biological activity, 2) its persistence, 3) its mobility, and 4) its solubility. (Eds.)

Let me talk about the significance of the solubility characteristics of DDT.

If DDT were a molecule with a high water solubility, we could afford to have a lot more of it around. We could lose it in those big oceans out there, because it would stay in the water; it would not come out of the water and go into living organisms. But it is not soluble in water, and so it has a tendency to be picked up by lipid tissue, which, in this case, is [found] in [all] living organisms. . . . from the plankton right on up through the various fish, birds, and so forth. All of these organisms have tissues that can dissolve more DDT into them than can be dissolved in water.

Examiner Van Susteren: All right. Now for the benefit of, first, the person who will study this record, "lipid" means fatty tissue?

Dr. Wurster: Lipid means fatty or fat-like. Lipids are usually defined by their solubility characteristics. So a lipid is something that tends to be soluble in a *nonpolar solvent* like hexane, or acetone.

Examiner Van Susteren: And it's l-i-p---

Dr. Wurster: L-i-p-i-d.

All living organisms contain lipids. Therefore, DDT is more soluble in living organisms than it is in water. This means, then, that all of the organisms in a body of water, whether it be a stream or river, a lake or an ocean, . . . are busy scrubbing the DDT out of the water and collecting it themselves. . . . This, then, explains why, when we look at the water, we don't find [DDT]. . . . But if we look at the organisms living in the water, there it is, sure enough.

So we have, then, a situation whereby this material spreads through the water [and] is constantly being taken out of the water and contaminating things that live. This also indicates that if you want to examine water quality, you don't examine the water, you examine the organisms that live there, because you are always going to be somewhere near the limits of detectability—the limits of your instrument—if you are looking at water. . . . So this is not the way to find out whether the water is of high quality. You should, instead, look at the organisms that live there. . . .

Now let me go through [my] four points and point out the significance of what this means. If we didn't have any one of these four key points, we wouldn't have the unique problem that we do with the chlorinated hydrocarbons.

Number one, the broad biological activity: If the [DDT] activity were restricted to the pest, then we wouldn't have to worry about non-target organisms, because if [DDT] reached them, it wouldn't hurt them. But it does have this broad biological activity; and so it can damage non-target organisms.

Secondly, if [DDT] were not stable, it would decompose before it ever reached [non-target organisms]. If we put [DDT] on a field of wheat or corn, by the time it had departed from the field, it

would have broken down into something non-toxic; and so, there again, it wouldn't reach many non-target organisms. But [DDT] is stable, and so it lives long enough to go a great distance from where you put it [to] contaminate non-target organisms a great distance away.

Thirdly, if [DDT] were not mobile, however toxic or stable it might be, it would stay where you put it, and, again, it would not reach non-target organisms. The fact that it is mobile means it can go away from where you put it and reach something else a long way off.

And finally, if [DDT] were not soluble in lipid tissue—and nonsoluble in water—we could spread it through the soils and bodies of water, and we wouldn't have to worry as much about it contaminating organisms. . . .

This morning we were talking about the organophosphates. Let's take a really bad actor like parathion. Here's an incredibly toxic material. . . . But it's really unstable, and in a matter of days or weeks it decomposes to relatively innocuous materials. It does not present the world problem that DDT does simply because it does not have one of those four characteristics; it doesn't have the stability, even though it's far more toxic than DDT ever was.

All right. Now there's one other thing that follows from what I said about the solubility characteristics that's also important to appreciate. And that is the phenomenon of *trophic level* concentration or biological concentration. Let us picture a *food chain*. . . . We will have, flowing out of the inorganic environment into that food chain, a certain amount of DDT, and it will flow in at all levels [of the] chain.

Let's say there are two different species of fish, one feeding on the other. Both of them will become somewhat contaminated [by] the environment. But the big fish is busy eating the little fish. Or the robin is busy eating the earthworm. And the robin eats many

Introduced only a quarter-century ago and spectacularly successful during World War II in controlling body lice and therefore typhus, DDT quickly became a universal weapon in agriculture and in public health campaigns against disease-carriers. Not surprisingly, by this time DDT has thoroughly permeated our environment. It is found in the air of our cities, in wildlife all over North America and in remote corners of the earth, even in Adelie penguins and skua gulls (both carnivores) in the Antarctic.
George Woodwell

earthworms. Or the big fish eats many little fish. The tissues of the prey are excreted, but he doesn't excrete DDT; he keeps it, because once again it's more soluble in him than in the material that is excreted. And so the DDT [from] many of the little fish becomes accumulated in that one big fish. . . . If you go out and look . . . at the big fish and the little fish on which he feeds, you will almost invariably—not invariably, but almost invariably—find the big fish has a substantially higher concentration of DDT than the little fish on which he feeds. And so, within a food chain, [concentration] tends to build as you go up the food chain. At the lower end of the food chain you often have low levels of DDT. When you go to the next link, you may multiply [the concentration] by two or three or ten or even a hundred. Now when you go to the next link, you multiply it again. So we have got a situation where food chains are having DDT fed into them at all levels, but [all DDT is] being concentrated up the food chain at the same time.

Let me give an example of how this works, a very simple example that occurred right here in Madison and [in] a number of other cities in the country. Spray DDT on elm trees. Some of the DDT lands on the soil beneath the elm trees, and the earthworms [busily take] it out of the inorganic parts of the environment. So, the earthworms become contaminated. The earthworms have a fairly simple nervous system, and so the DDT may very well not kill the earthworms. Along come ground-feeding birds like robins and chipping sparrows and others. They feed on the soil organisms including the earthworms, and they become contaminated. And so we have a fairly simple food chain effect.

It's not always that simple: that's a very nice simple classic example.

But let's talk about another one. This is some work that I did myself on Long Island. . . .

Mr. Yannacone: Would you identify this paper for the record?

Dr. Wurster: It's a paper by George Woodwell, myself, and Peter Isaacson in *Science*, Volume 156, page 821, 1967.

Examiner Van Susteren: Entitled?

A: Entitled "DDT residues in an East Coast estuary: A case of biological concentration of a persistent insecticide."

In analyzing for DDT residues we analyze[d] quite a number of organisms, and we then arrange[d] in a table . . . the---

Examiner Van Susteren: That's on page?

A: Page 822.

---we arrange[d] in a table the organism analyses in the order of increasing [DDT] concentration. And lo and behold, by doing so, we, in effect, put the food chain in order. . . . I will read just a few examples of how this works.

Examiner Van Susteren: Slowly.

A: Slowly.

The zooplankton, a small crustacean, has four hundredths, .04 parts per million of DDT. That's 40 parts per billion. The shrimp, the larger crustacean, some of whom are presumably feeding on those smaller ones, have four times as much, 0.16 parts per million [DDT].

Let's go a bit further here to some small fish, the needlefish or a pickerel. The pickerel had 1.33. The needlefish 2.07. You see, we have moved the decimal point over three times already. We have gone through three orders of magnitude.

Going further, we have the terns. The common tern is feeding on small fish. The red-breasted merganser is a diving duck that feeds on larger fish. The red-breasted merganser had 22.8 parts per million of DDT residues. The double-crested cormorant had 26.4 parts per million.

So, in going from the water to the top of this food web, we have a concentration effect of, approaching one million. So you see how efficient this system of uptake is, in going from the inorganic environment of exceedingly low concentration to important concentrations toward the top of the food chain.

Table 1. DDT residues (DDT + DDE + DDD) (*1*) in samples from Carmans River estuary and vicinity, Long Island, N.Y., in parts per million wet weight of the whole organism, with the proportions of DDT, DDE, and DDD expressed as a percentage of the total. Letters in parentheses designate replicate samples.

Sample	DDT residues (ppm)	Per cent of residue as		
		DDT	DDE	DDD
Water*	0.00005			
Plankton, mostly zooplankton	.040	25	75	Trace
Cladophora gracilis	.083	56	28	16
Shrimp*	.16	16	58	26
Opsanus tau, oyster toadfish (immature)*	.17	None	100	Trace
Menidia menidia, Atlantic silverside*	.23	17	48	35
Crickets*	.23	62	19	19
Nassarius obsoletus, mud snail*	.26	18	39	43
Gasterosteus aculeatus, threespine stickleback*	.26	24	51	25
Anguilla rostrata, American eel (immature)*	.28	29	43	28
Flying insects, mostly Diptera*	.30	16	44	40
Spartina patens, shoots	.33	58	26	16
Mercenaria mercenaria, hard clam*	.42	71	17	12
Cyprinodon variegatus, sheepshead minnow*	.94	12	20	68
Anas rubripes, black duck	1.07	43	46	11
Fundulus heteroclitus, mummichog*	1.24	58	18	24
Paralichthys dentatus, summer flounder†	1.28	28	44	28
Esox niger, chain pickerel	1.33	34	26	40
Larus argentatus, herring gull, brain (d)	1.48	24	61	15
Strongylura marina, Atlantic needlefish	2.07	21	28	51
Spartina patens, roots	2.80	31	57	12
Sterna hirundo, common tern (a)	3.15	17	67	16
Sterna hirundo, common tern (b)	3.42	21	58	21
Butorides-virescens, green heron (a) (immature, found dead)	3.51	20	57	23
Larus argentatus, herring gull (immature) (a)	3.52	18	73	9
Butorides virescens, green heron (b)	3.57	8	70	22
Larus argentatus, herring gull, brain‡ (e)	4.56	22	67	11
Sterna albifrons, least tern (a)	4.75	14	71	15
Sterna hirundo, common tern (c)	5.17	17	55	28
Larus argentatus, herring gull (immature) (b)	5.43	18	71	11
Larus argentatus, herring gull (immature) (c)	5.53	25	62	13
Sterna albifrons, least tern (b)	6.40	17	68	15
Sterna hirundo, common tern (five abandoned eggs)	7.13	23	50	27
Larus argentatus, herring gull (d)	7.53	19	70	11
Larus argentatus, herring gull‡ (e)	9.60	22	71	7
Pandion haliaetus, osprey (one abandoned egg)§	13.8	15	64	21
Larus argentatus, herring gull (f)	18.5	30	56	14
Mergus serrator, red-breasted merganser (1964)†	22.8	28	65	7
Phaldcrocorax curitus, double-crested cormorant (immature)	26.4	12	75	13
Larus delawarensis, ring-billed gull (immature)	75.5	15	71	14

*Composite sample of more than one individual. †From Captree Island. 20 miles (32 km) WSW of study area. ‡Found moribund and emaciated, north shore of Long Island. §From Gardiners Island, Long Island.

George M. Woodwell, Charles F. Wurster, Jr. and Peter A. Isaacson, "DDT residues in an East Coast estuary: A case of biological concentration of a persistent insecticide," *Science* 156(1967): 822. By permission.

Examiner Van Susteren: Now wouldn't some of the lower forms have just a small amount of lipid tissue?

A: Per cell, no.

Examiner Van Susteren: You do this on a per cell basis?

A: There may, in some cases, be some more lipid toward the top, but I don't think you could make that as a general rule. The major factor here is not uptake from the environment so much as biological concentration as far as the carnivore at the top is concerned. This is a larger factor than the uptake from the water, because if you take a cell or take an organism like the small crustaceans, they are not concentrating [DDT] so much through the food chain, and their amount is very low as compared to the [organism] at the top which could possibly be taking that much out of the environment directly.

Examiner Van Susteren: But the lipid tissues would be less?

A: [In] the one at the bottom? Not necessarily. In some cases I suspect so; but not necessarily.

Examiner Van Susteren: But the study was done on a cell basis?

A: On a whole organism basis.

Examiner Van Susteren: On a whole organism---

A: Yes, but [the] parts per million [figure] is not absolute in the organism.

Examiner Van Susteren: [Yet the study] wasn't done on a cell by cell basis?

A: No. This is the more or less conventional way of analyzing for total contamination. [You take] the whole organism—take a fish—grind him up . . . and analyze the sample of that ground-up fish.

Examiner Van Susteren: So then what you are saying is it wouldn't make any difference if the whale had two feet of blubber or had one inch. You are saying the DDT is concentrated in the lipid tissue.

A: Yes. But blubber is not the only kind of lipid tissue.

Examiner Van Susteren: I realize that. But you said that DDT was concentrated in lipid tissue, and the amount of lipid tissue in the zooplankton . . . would certainly be less than in a duck.

A: Yes, but we are talking about parts per million. I'm talking about a gram of fish versus a gram of zooplankton. In other words, we are not talking about absolute size. Insofar as a whale is concerned, if he has enough blubber, he can store quite a bit of DDT on an absolute basis.

All right. Let me give one somewhat more esoteric situation to show the effect of not only distribution and mobility, but biological concentration.

In the middle of the Atlantic Ocean is a bird called a Bermuda petrel.* It's a very rare bird [with] only some hundred of them

*C. F. Wurster and D. B. Wingate, "DDT residues and declining reproduction in the Bermuda petrel," *Science* 159 (1968): 979–981.

in the world. [It] is a completely pelagic (oceanic) bird. [It] does not come to land except to breed; and when it does so, it breeds on some very small islands; they are hardly bigger than this room; they are essentially rocks. This is the only time the Bermuda petrel touches land. It does not come close to our coastline, and so it is in no way in contact with any agricultural area or any [DDT] treated area of any kind.

The only effective way this bird can accumulate important amounts of DDT is through its food chain. The bird feeds mainly on cephalopods (small squids), and probably feeds on some fish as well. But [the petrel] is probably the top link in perhaps a four-step food chain, but a wholly oceanic food chain, not a coastal one in any regard. . . .

This bird, by the analyses of six specimens—we would like to have more, but we can't very well take samples of a population that is bordering on extinction—averaged 6.4 parts per million [DDT] in its eggs and its dead chicks. These were not live specimens, they were dead ones. We did not want to take any live specimens.

The point of this is that it shows that DDT is an important contaminant or pollutant in the oceanic food chain at this point. There is clear evidence—not just [this], there is other evidence—that DDT is an important factor in the contamination of the oceans at this point.

That summarizes my prepared presentation.

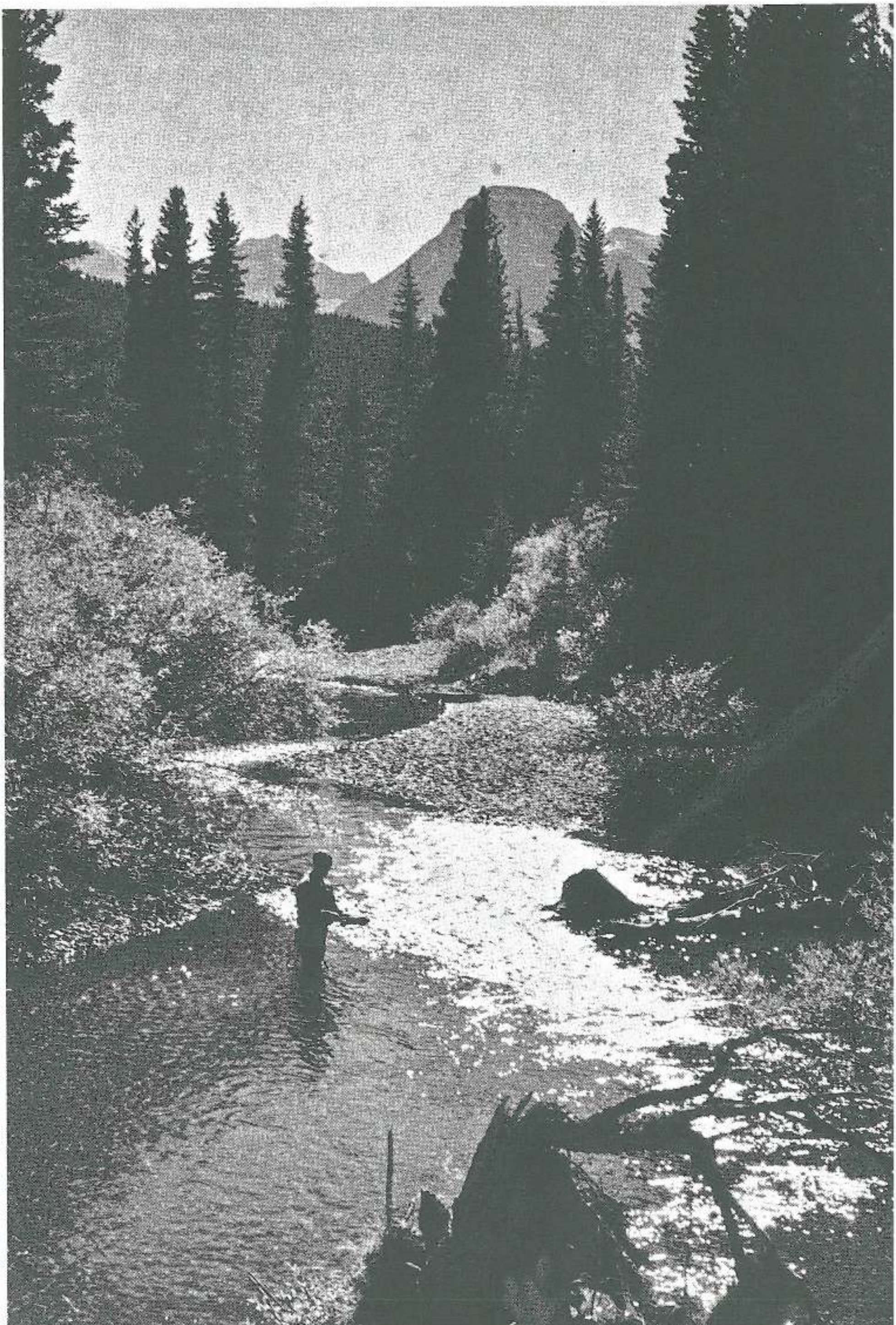
Mr. Yannacone: All right, Doctor, is there anything else you might want to add about the physical and chemical properties of DDT as they relate to the impact of DDT on the environment?

A: I think that the DDT picture at this point has become extremely serious, much more than is generally realized. I think it has become a very substantial threat to a number of organisms, particularly among birds and fish. . . .

Mr. Yannacone: All right, Doctor, thank you.

Examiner Van Susteren: Mr. McLean?

Mr. McLean: Thank you, sir.



4

Wurster's Cross-examination

Louis McLean, billed in advance as the Task Force's hatchet man, seemed to epitomize to many people the DDT industry's waspish approach to any criticism of its products and techniques. And, true to that image, in cross-examining Wurster, McLean launched a stinging attack but, like a veteran club fighter just searching for an up-and-comer's weakspot, he first asked Wurster a few general questions.

Mr. McLean: Have you obtained some of your background information on the general subject of pesticides as a result of your association and work with the Environmental Defense Fund?

Dr. Wurster: Have I gotten the information from the Environmental---

Q: I say, have you gained this in connection with your association with the—part of your background?

A: I don't understand what you mean. You mean, has the Environmental Defense Fund been a part of my education?

Q: Have you gained this information in your activity for the Environmental Defense Fund?

A: Oh, yes, in contacting other scientists, definitely.

Then McLean threw his first kidney punch.

Q: Did you gain information on this subject in September of this year in Suffolk County, Long Island, when the Environmental Defense Fund filed an injunction suit in the courts there to enjoin the use of malathion for the control of mosquitoes---

What didn't make the hearing record in the uproar that ensued was the hooker at the end of McLean's question: he claimed that there was an encephalitis epidemic on Long Island at that time.

Mr. Yannacone: May I object at this time. I am counsel to the Environmental Defense Fund and as long as I have been with the Environmental Fund—since it was incorporated—the Environmental Defense Fund has never filed any suits on malathion.
Now let's take that again, sir.

Mr. McLean: I will get into that in a minute.

Examiner Van Susteren: You want to complete your question and---

Mr. McLean: ---while an encephalitis---

Mr. Yannacone: I am going to object to that question---

Mr. McLean: May I complete my question?

Mr. Yannacone: ---unless Counsel can prove there was such a case brought by the Environmental Fund.

Examiner Van Susteren: Do you know?

Dr. Wurster: Yes, I can answer, no. . . . There was no such case brought by the Environmental Defense Fund. And I hope there isn't going to be and I do not get information from the---

In fact, as I recall, I was out of town. I was in Africa while that occurred; it came up while I was gone. I had nothing to do with it, nor did the Environmental Defense Fund.

Mr. McLean: Thank you. Do you know---

Mr. Yannacone: May I please, on the question, Mr. Examiner, on the question the witness was just asked---

Examiner Van Susteren: He just answered it.

Mr. Yannacone: All right. I'd be happy to submit a court record in that case.

Mr. McLean: The Environmental Defense Fund did not file this case either, but you are active as an organization for the petitioners, is that correct?

Dr. Wurster: Not entirely. That case was one where EDF---

Mr. Yannacone: I'm going to object. What are we talking about? The [case] here today---

Dr. Wurster: Both.

Mr. Yannacone:---or a case on Long Island? Or talking about a dieldrin case of last month?

Examiner Van Susteren: First of all, we should find out what connection, if any, Dr. Wurster has with EDF.

A: I am a member of the Board of Trustees of EDF and chairman of its scientist advisory committee.

Mr. McLean: And you were one of the original organizers of EDF, were you?

A: That's right.

Q: Do you know if EDF played any part in support of the lawsuit filed for an injunction against the use of malathion for mosquito control in Suffolk County, New York?

Mr. Yannacone: I'm going to object until he establishes there's been such a lawsuit.

Examiner Van Susteren: He's asking the witness if, in fact, a lawsuit has been started by the Fund. And certainly the witness would be qualified to know.

Dr. Wurster: EDF had no role whatsoever in the suit concerning malathion.

Its role here is, by formal resolution of the trustees, one of involvement. In other words, EDF is a part of this. In other words, we are not just sort of sneaking in the door and pretending not to be here. We are here.

Mr. McLean: All right.

Examiner Van Susteren: Well, the EDF is not one of the petitioners.

Dr. Wurster: That's right, we are here by invitation.

Mr. Yannacone: He filed an appearance.

Examiner Van Susteren: They filed an appearance as an intervenor.

Mr. McLean: Dr. Wurster, among your publications do you include a cartoon book, collaborating with several people including Dr. Woodwell, a cartoon book that was distributed gratuitously, but without invitation, at any of the science meetings in 1966? . . .

Now, Dr. Wurster, this cartoon book which is entitled *A-Bombs, Bugbombs, and Us* bears on the inside—I guess you'd call it actually the first page—G. M. Woodwell, W. M. Malcolm and R. H. Whittaker, Biology Department, Brookhaven National Laboratory, Upton, New York. You are not shown as a co-author at that point, are you?

A: Right.

Q: Are you shown as a co-author later in this book?

A: No.

And so it was to go through four days of cross-examination. McLean would alternate tacks: first the technical and scientific, then the political or social one. But this approach was to prove very dangerous for McLean. The harder he tried to nail Wurster, the more questions he asked. And the more questions he asked, the more information Wurster could pour into the record from his voluminous knowledge of the literature about chlorinated hydrocarbons.

But McLean persevered. In one segment of the cross-examination he tried to nail Wurster on the title he had given himself, "molecular ecologist."

Q: Let me ask you about that term. That's a new scientific term. I believe you said you had just conferred that degree on yourself.

"Molecular," I believe, refers to something rather small. Isn't a molecule rather small?

A: Usually.

Q: And the ecosystem, which has the same [root] as ecologist, would be something rather big. This would conclude then, [if] my translation is correct, knowing a little about a great many things, kind of a jack-of-all-trades, is this it?

Examiner Van Susteren: Can you answer the question?

A: I don't know what to do with it.

I told somebody that I seem to be learning less and less about more and more and pretty soon I would know nothing about everything, but---

Cross-examination can be a very rough business. It gives prospective witnesses an incentive to be well prepared and confident of the validity of their testimony—or not testify at all.
Charles Wurster

Mr. Yannacone: Your Honor, I'm going to submit at this time that . . . we ought to give the witness or someone the opportunity to explain that there is in common usage today the phrase "molecular biologist," and it has a very definite meaning.

Examiner Van Susteren: He said "molecular ecologist."

Mr. Yannacone: And this happens to be the phrase "ecologist." This is the first time I have ever heard the combination of the two. I think we ought to give the witness the opportunity to fully explain them---

Dr. Wurster: Well all right---

Mr. Yannacone ---without the ridicule of Counsel.

Examiner Van Susteren: Counsel is not ridiculing. There are several people in the audience who are snickering, but they will be cautioned to keep their humor to themselves in this situation.

Could you explain the difference to us [between] molecular ecologist and molecular biologist?

A: Molecular biologist, in common usage, is often a molecular geneticist. My idea of a molecular ecologist is one familiar with the field of molecules or biochemistry with some capability in ecology; in other words, the ability to combine the two, or at least to try to do it. We have found, or we are finding, that biochemical systems have extremely important ecological consequences, so it's becoming vital to combine them, if not in one person, in many people. But it's essential that there be interdisciplinary cooperation and crossing of lines, because it's become extremely clear that biochemistry plays a vital ecological environmental role.

Mr. McLean: I understand biochemistry—and I'm not trying to be cute with you—but I would like to distinguish how you term yourself. You do not, in calling yourself a molecular ecologist, consider yourself as a medical toxicologist?

A: No.

Q: You have no medical training?

A: No.

Q: Nor do you consider yourself a plant pathologist?

A: No.

Q: I assume you took some courses in statistics, but you don't consider yourself a statistician?

A: I did not take any courses in statistics.

Q: You do not consider yourself an entomologist?

A: No.

Q: Nor an ornithologist?

A: I often consider myself as an ornithologist, yes.

Q: I assume you would consider yourself a biologist?

A: Yes, I am an assistant professor of biological sciences, so by definition that makes me a biologist.

Q: Biology is a rather broad field that covers a lot of things and touches very few in a great degree, just like ecology is . . . also a very broad area, is that correct? And I believe you already said you do not classify yourself as an expert in analytical chemistry?

Examiner Van Susteren: You said, yes?

A: Yes. But that doesn't mean I have never had anything to do with analytical chemistry. It means I don't consider myself a specialist in analytical chemistry.

Mr. McLean: Do you consider yourself as an expert even if not a specialist?

A: Somebody else will have to judge whether I'm an expert in anything.

Pursuing his zig-zag course, McLean went after Wurster from a different angle. Bringing up the subject that was, in many ways, the key to the industry's defense of DDT, McLean suggested that polychlorinated biphenyls (industrial compounds, frequently found in the environment) were interfering with analyses for DDT, thereby invalidating the research on which the anti-DDT forces based their case. When this was sidestepped, McLean directed his examination to the difficulties involved in—even the impossibility of—determining the existence of DDT in an organism, when present in infinitesimal quantities.

Q: You referred to quite a bit of DDT residue data findings in your direct testimony. What I wonder is, are the data giving the amounts of DDT that you referred to irrevocably clear or did you have artifacts such as polychlorinated biphenyls (or PCBs).

A: I would like to refer questions on the polychlorinated biphenyls to Dr. Risebrough, who will be our next witness.

Q: Well isn't it certain that polychlorinated biphenyls are used as plasticizing agents?

A: That's correct.

Mr. Yannacone: I'm going to object. The witness has testified that he does not wish to talk about the polychlorinated biphenyls, and on direct examination he did not discuss the polychlorinated biphenyls. Unless Counsel is ready right now to show polychlorinated biphenyls have some relevancy, he can't ask the question.

Examiner Van Susteren: Let's give Mr. McLean a chance. Apparently there's some possibility of confusion in determination of levels as to whether they are DDT or DDD or polychlorinated---

Mr. McLean: In an examination for DDT, DDD, and DDE residues, may not polychlorinated biphenyls interfere as artifacts?

A: It depends which column you are using.* In some cases they may, in other cases they may not.

Q: And when you referred to your findings . . . and analyses, had you made a subtraction for the polychlorinated biphenyls? [Had you gone] through processes to eliminate them?

A: Yes.

Q: Would you describe how you eliminated them?

A: By confirming the identity by *thin-layer chromatography.*†

By this point, McLean was beginning to realize the opportunity that Wurster was getting to fill up the hearing record with evidence damaging to DDT. Yet, he continued. After considerable testimony on the accuracy of DDT detection equipment when used to measure varying samples, McLean asked:

Mr. McLean: What you call a peak "in the parts per billion range" [is a] pretty large peak?

A: When you are talking about a substance like ortho, para-DDT, which has been shown by the Department of Agriculture recently and by the Burroughs Wellcome Laboratory along the Hudson River in New York to have estrogenic activity and to have it at exceedingly low concentrations, then the parts per billion range is certainly one to give very serious thought about.

There was a recent estimate; in fact this was an estimate in the paper by Bitman and several other authors recently published in

*This statement refers to the processes of chromatography. For further explanation see the glossary, page 219. (Eds.)

†For a further discussion of this subject, see Dr. Risebrough's testimony, page 59 and the glossary.

*Science** (Bitman and these other authors are at the U.S.D.A. Laboratory in Beltsville, Maryland) . . . that in the world environment there was circulating something in the neighborhood of 200 million pounds of an estrogenic substance. And we have just discovered in the last year that DDT is an estrogenic substance.

Now this may to you seem to be insignificant. But to scientists this is not insignificant. This is a very alarming situation. . . .

It may be all right for you to say this is---

Mr. McLean: If the Court please---

Examiner Van Susteren: Now just a moment. We are getting into an argument.

Mr. McLean: Dr. Wurster, I don't want to get to the point of asking you just to give me a simple yes or no answer. But if you are going to give me extremely long and ranging answers to a question which I would hope to be answered rather simply, your answers are necessarily going to extend my cross-examination of you.

And I would appreciate it if you would---

A: When---

Mr. Yannacone: Your Honor, I respectfully request at this time that the Court instruct the witness that if the question cannot be answered yes or no, he need not answer yes or no.

Examiner Van Susteren: He may also ask for an opportunity to expand or amplify.

But as the questions continued to come from McLean and the answers voluminously from Wurster, the record grew fat with information about DDT and ecological problem solving.

Mr. McLean: Now Doctor, I believe when we adjourned yesterday, I was inquiring as to your familiarity with other factors that affect wild populations. Had we gotten to the botfly? Or are you familiar with any damage that the botfly does to wild populations?

A: Sir, I think I need to answer that at some length.

It seems to me your line of questioning is completely missing the point with regard to what the environmental sciences are all about---

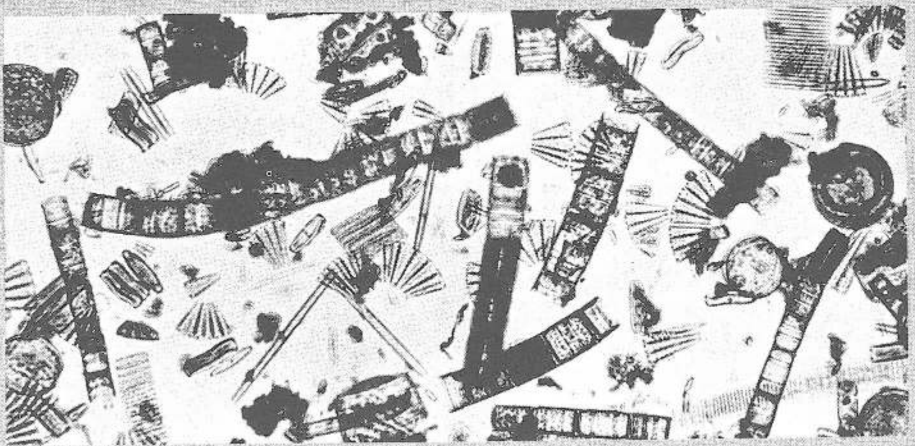
Examiner Van Susteren: Now that's argument, Dr. Wurster. Can you answer Mr. McLean's question?

Mr. Yannacone: Your Honor, I think [your question] should be just can he answer yes or no [or] does he require an explanation?

Examiner Van Susteren: If he wants to answer yes or no and provide an explanation, then he can do so.

Dr. Wurster: All right, then let me answer this way. I will say no, I do not know much about botflies. I am not an entomologist.

*J. Bitman, et al., "Estrogenic activity of o, p' - DDT in the mammalian uterus and avian oviduct," *Science* 162 (1968): 371–372.



phytoplankton

Durable pesticides such as DDT tend to be concentrated when passed up the food chain from plants to small organisms to larger predators; they may reach levels sufficient to wipe out entire species of the animal population.
George Woodwell

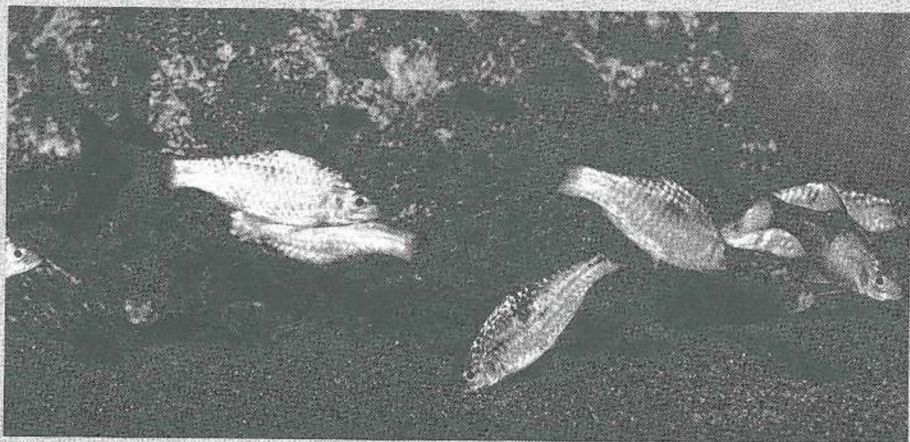
I would like to further say . . . why I don't know about botflies. The environment is an extremely complex system. We are only beginning to understand what makes it tick. It consists of a vast array of factors, the appreciation of which requires a great number of specialists. To appreciate this environment, we have got to have botanists and ecologists, zoologists, ichthyologists and ornithologists; we have got to have statisticians and entomologists, agricultural experts, meteorologists---

Examiner Van Susteren: But now, this does not refer to the question.

A: I will get to it, I think.

No one person can concentrate sufficiently in any one field to begin to grasp the complexity of this [system]. And so an environmental scientist must be in the position of being in constant contact with the free flow of information [between] experts and specialists in every conceivable field. Now this I think goes to the heart of the pesticide problem. We are dealing with people in a position to make decisions who are specialists in a narrow field. They may be so simple as to know only that there is a pest and a chemical that will kill it. They are not in contact with the rest of the scientific community.

The environmental scientist is in constant contact with the rest of the scientific community, and my role then is to constantly contact others. If I need to know about a botfly, I am going to have to call up somebody who knows much more about botflies



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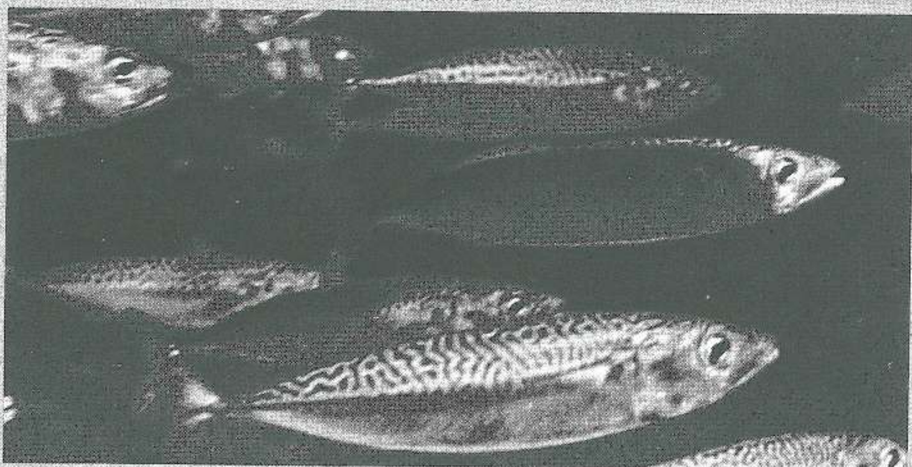
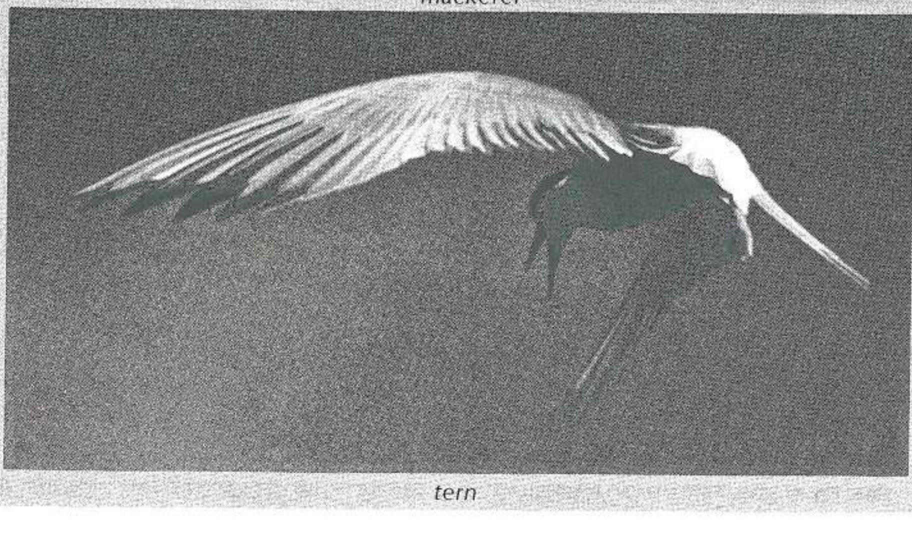


mackerel



tern

and entomology than I do. And I'm going to have to evaluate whether that individual is competent, whether I should accept his judgment, or whether I should call a different entomologist after the first one.

I am constantly doing this sort of thing. [So] when you [ask] me about narrow specialties like this, you are not really getting to the heart of the issue, I don't feel.

Now let me give you some idea of how the environmental scientist works. Nobody could consider me an algologist, nobody in his right mind.

Q: Could consider you a what?

A: An algologist.

Q: Dealing with algae?

A: That's right. Yet, for about the past two years I [have] been rather suspicious that DDT had something to do with the base of the oceanic food chains. I hadn't the slightest intention of looking into it. I just had been wondering what goes on with[in] the phytoplankton communities in the oceans. And suddenly I found an opportunity to look into this question.

I spent the summer of 1967 at the Woods Hole Marine Biological Laboratory. I had access to the best scientists in the world with regard to algology. They were people who had spent their lives working with marine phytoplankton. I therefore realized that I was in a position to begin to look into the phytoplankton question. I considered this extremely important; it seemed to me that [it] was something that had to be done, because here you have the phytoplankton conducting something like 70% of the world's total photosynthesis. That means that the phytoplankton are responsible for 70% of the carbon fixation on this planet. They are responsible for 70% of the oxygen in the atmosphere and 70% of the removal of CO_2. So these little floating algae in the world's oceans and coastal waters are obviously of exceedingly vital significance.

I therefore felt it important to look into this question. And yet here I was without competence, suddenly . . . essentially by chance, . . . in the best place on earth, just about, to conduct some experiments.

Q: Well---

A: I will get to your botflies.

And so I looked into four different species of phytoplankton. I investigated diatoms; some little things called *coccolithus* (that's the genus *coccolithus*); a green alga; and a dinoflagellate. These were representative of four major groups of algae. They are major food items for the various marine animals. They are representative of the base of oceanic food chains.

The results of these experiments were, in a few words, that a few parts per billion of DDT in the water reduce the photosynthesis [occurring in these algae]. By the time we were up to 10 to 15 parts per billion in the water, the photosynthesis of these algae was down in the neighborhood of 30 to 40% of normal. . . .

Now if I had not been in the Woods Hole Research Laboratory and I had decided I would like to go into that question about the phytoplankton, it would have taken me a year before I could have even gotten those things to grow. I don't have a competency in algology.

But I worked right in the laboratory with Robert Guillard. He's a world authority on phytoplankton. And so the first time that I grew these cultures, they grew, they worked. I was able to employ the services of his technician who has been doing this for years. And she knows how to prepare the medium [on which the algae grow] so it will work. So I was able to conduct experiments in two months that otherwise would have taken me two years.

Now let me read from the back of this paper which is in our technical---

Q: Which paper are you referring to?

A: I am referring to a paper called "DDT reduces photosynthesis by marine phytoplankton." It's from *Science* Volume 159, page 1474.

Q: And what was the date?

A: The date is 29th March 1968.

Now this was written by me, alone, as a single author. But that doesn't really tell the story. The story is told really in the acknowledgement which says, "I think, the Woods Hole Oceanographic Institution---

Q: I'm going to have to interrupt. I'm sorry, Dr. Wurster, I don't like to interrupt a witness. But I'm going to have to make a request at this time that when you, as you refer to studies extemporaneously, I think that Counsel will agree they should be made available so I have a chance to read them.

Examiner Van Susteren: Well that's far afield from the botfly. Could we get back to the original question that Mr. McLean asked in regard to botflies?