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The Human Watchers

Although the pesticide industry had, in one form or another, eleven witnesses speaking in behalf of DDT, their case really rested with two men: Harry Hays, head of the U.S. Department of Agriculture's Pesticide Registration Division, who was called to show how well the public was protected from the harmful effects of all pesticides;* and Wayland Hayes, who was there to assert that pesticide protection for man—at least in the case of DDT—wasn't really necessary, anyway. If either of these men could have gotten off the Madison witness stand with their testimony on the safety of DDT to man relatively unscathed, there would have been hope for the future of DDT, no matter what material the petitioners massed on DDT's effects in nonhuman species. For, to the majority of the public, concerned with its human problems, damage to birds and fish and plants would have seemed relatively insignificant. However, these two men did not get off unscathed.

Wayland Hayes, billed by Task Force attorney Willard Stafford as the "world's top toxicologist," had long been a major thorn in the side of the critics of DDT. In the past, whenever the debate over DDT's effects had become too hot and heavy, this dignified southern Public Health Service physician would reassuringly appear and, with best bedside manner, would dutifully inform the public that he himself had conducted extensive tests with DDT on humans, and the stuff, at the levels at which it was being found in the environment, simply wasn't dangerous.

Since his data was really all that had been available in this particular area, ecologists and other hard-pesticide critics had always found combat very difficult. Too often, DDT's critics were made to look like callous scientists, willing to sacrifice the well-being of the hungry masses of the world to the survival of a few birds.

It was essential then, that the Madison petitioners, unlike their predecessors, successfully discredit Hayes's testimony and to do so they were forced into a two-part battle. To dispel the lingering image

*See Chapter 10.

of callousness, the petitioners had to prove that DDT was not essential to crop success and disease control; to rally public support, the petitioners had to prove that DDT could, indeed, be considered a hazard to humans as well as to other species. These battles, contested hotly by both the DDT industry and the environmentalists, were what raged so fiercely in and around the testimony of Wayland Hayes.

For Yannacone, planning crucial cross-examination tactics at a time when the effects of DDT on humans were really little more than hypotheses in the minds of a few far-seeing scientists, campaign strategy was frightfully difficult. Primarily, it consisted of deluging the hearing room with enough inferential data on possible human health hazards and establishing enough doubt as to the thoroughness of Hayes's research, to insure the fact that Hayes's findings would never again be held in the esteem they had once been.

Wayland Hayes had received his Ph.D. from the University of Wisconsin in 1942 and his M.D. from the University of Virginia in 1946. He was then employed by the U.S. Public Health Service from 1947 to 1968, when he became a professor of biochemistry at Vanderbilt University.

Under direct examination by Stafford, Hayes listed a number of the papers he had authored and co-authored, and others which corroborated his findings on DDT and humans: "The effect of known repeated oral doses of DDT in man"; "Storage of DDT and DDE in people with different degrees of exposure to DDT"; "Storage and excretion of DDT in starved rats"; "Storage of insecticides in French people"; "Poisoning by DDT: relation between clinical signs and concentration in rat brains"; "DDT storage in the U.S. population"; "Chlorinated insecticides in the body fat of people in India"; "Mortality from pesticides in 1961"; "Monitoring food and people for pesticide content"; "Toxicity of pesticides to man"; "Combined effect of DDT, pyrethrum and piperonyl butoxide on rat liver"; "The pesticide content of human fat tissue"; "Coordination of activities relating to the use of pesticides." These papers made up the bulk of the Gospel according to Hayes.

Stafford then began delving into the substance of the work Hayes had done himself or had monitored, starting off by asking of him a conclusion:

Mr. Stafford: Have you an opinion, based upon a reasonable scientific certainty, whether DDT as now used in this country presents a health hazard to the people?
Dr. Hayes: Yes, sir, I have.
Q: What is your opinion?
A: I think it's safe.
Q: And will you state your reasons, please, in some detail?
A: Well, DDT is used in agriculture, it's used as a pesticide in the home, and in various other ways. No matter how people are

exposed, no matter how it is used, insofar as they are really exposed to the compound, they will absorb some fraction of this material. Therefore, one can evaluate the total exposure in terms of storage of the material measured chemically in samples from people. (I might add [DDT] was used for the control of malaria in this country with great success; and malaria is now eradicated in this country; and so it is no longer used for that purpose here, but it's important for that use in other countries.)

Now going to storage: We have measured the storage of DDT in people in the general population, in people with unusual dietary habits, in volunteers who were given known doses of DDT, and in workers who worked in the manufacture and formulation of this compound and therefore had exposure of a very intense kind for many years.

Then Hayes went into the technicalities of the dosages given volunteers and summarized by saying:

Dr. Hayes: The conclusion was that we could find no effect on the men clinically [caused] by DDT. They complained of no effect that could be traced to this compound. And we examined them [medically] and did a number of laboratory studies on them.

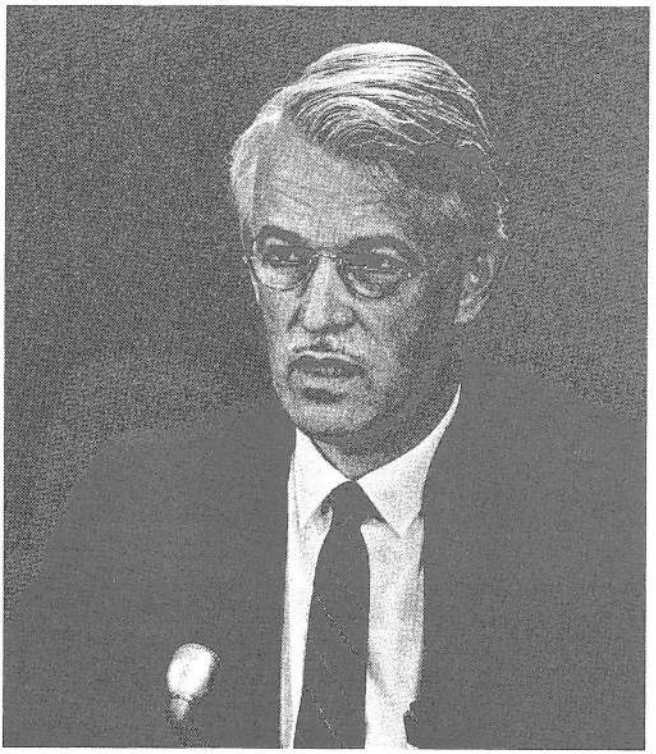
Hayes stated that the dosages fed the volunteers who were, in some experiments, prisoners in sourthern penal institutions, were approximately 200 times what the general population was receiving environmentally at the time. He cited workers in DDT plants who had worked with the compound for over six years and other workers who had been exposed to high levels of the chemical for as long as 19 years, saying that his neurological examinations were "unable to detect any effect on their health." He continued:

Dr. Hayes: As I have said, we could find no effect either by our examination or by examination of their work record. And work record is a rather sensitive measurement of people's physical ability. You find that when they are sick they don't go to work very well.

Mr. Stafford: Now there's been some suggestion in this proceeding—at least it involves certain raptor hawks—that there may be some reproduction problems associated with DDT. Did you find any reproduction problems amongst this group of workers or volunteers?

A: . . . We did assure ourselves that these men in the course of 19 years, for the majority of them, had in fact had families of quite adequate size, a bit above the average as I understand it. . . .

Q: Are there any other studies which you have not referred to which substantiate your conclusion that DDT does not affect health in people?



I think that for people in the general population, [DDT] is completely safe. . . .
Wayland Hayes

A: [DDT] has been used, of course, in disease control in other countries in a variety of ways. The three major diseases that have, in fact, been controlled by it are malaria, plague, and typhus. Its use in these diseases is quite different.

In malaria control, to a very large degree, it is used as an indoor house spray. This involves really little or no increase in exposure of people.

Again, in the control of plague, it is used in the environment and there is very little personal exposure except in workers who use the material.

But in the control of typhus, it's necessary to dust the people. The first time that an epidemic of typhus was controlled or stopped in all history was in Italy during the latter part of World War II. People were dusted with power dusters; thousands of them had DDT dust blown into their clothes, through the collars and the cuffs and down their pants, so that they were pretty well saturated with the powder. . . . The experience with this was that it not only, in fact, did stop this very epidemic disease, but that there were no ill effects from its use. . . .

Then Stafford led Hayes to a discussion of what DDT does in the human body:

Q: Doctor, physiologically, what happens to DDT when it is taken into the human body?

A: Well, like any other drug or chemical of any kind that is absorbed, it is distributed to all tissues; and the concentration it reaches in different tissues depends on the dosage and also on the chemical nature of the tissue. Because DDT is chemically remarkably inert and because it is highly soluble in fat, it is stored in fat to a much higher degree than in other tissues. This is particularly true following repeated doses, which give an opportunity for this accumulation in the fat to occur.

[DDT] is also and at the same time metabolized or broken down into simpler—and it turns out more water soluble—materials which can be excreted. And so as soon as it's absorbed, some excretion begins. The excretion is—the metabolism is—of, I should say, moderate efficiency. As with other materials of this sort, there is some accumulation in the tissue following repeated dosages.

Now because the rate of metabolism, the rate of excretion [is] related to the concentration in the body and not directly to the dosage, . . . the accumulation in the tissues increases rapidly at first and then more slowly, and gradually reaches a steady state, because the concentration in the tissue has now reached a point high enough to determine a total excretion of as much material per day as is taken in per day.

Q: Are you saying then, in the general population, the amount of DDT stored by the average human being has reached or does reach a plateau?

A: That is true. . . .

Hayes began talking about the amounts of DDT stored in humans and how the amounts had actually decreased in the past few years, after sharply rising for the first few years after the compound was introduced into widespread agricultural use. He then talked about the Michigan coho salmon, impounded by the Food and Drug Administration during the hearing recess because of DDT levels averaging 19 ppm, and said that this concentration would not be harmful. As evidence of this, Hayes stated that the factory workers he had studied had a higher DDT intake; therefore, even if inveterate fish eaters ate 2.2 pounds of salmon per day, they would be in no danger. Hayes continued by examining data on DDT levels in Wisconsin fish, reiterating that, in his opinion, no matter how much was eaten, consumption of fish containing DDT at present levels would not harm human beings.

After this scientific interlude, Stafford tried to bring up the matter of DDT's efficiency in controlling disease, and the possible effect a ban of the substance might have on the underdeveloped countries

where great amounts of DDT are still being used. However, Yannacone successfully objected at almost every turn, claiming either that this was a political matter or outside Hayes's competence.

Shortly after the laborious infighting over insect-caused diseases was over, Yannacone began his cross-examination. He quickly set a tone which he kept throughout Hayes's ordeal.

Q: Dr. Hayes, do you really consider yourself the world's foremost toxicologist?
A: That isn't really a question for me to answer.
Q: Oh, Doctor, that is a question for you to answer. I want an answer.

Naturally, Stafford objected, and naturally, Van Susteren sustained the objection.

Arguments, which flared bitterly during the Hayes cross-examination, began almost immediately, starting over the definition of a qualified toxicologist. Hayes claimed he knew of no qualified toxicologist who differed with his views. Of course, this brought bellows of disagreement from Yannacone, and the squabbling continued uninterrupted until the Hearing Examiner interjected: "Both Counsel sit down and be quiet." In the days before Judge Hoffman, a Hearing Examiner's wishes were obeyed.

Yannacone next brought up the subject of safety and dosage to which Hayes replied:

Dr. Hayes: Well, in toxicology it's generally recognized that safety has to be determined in terms of dosage; because there is no material which is not dangerous when given in excessive dosage; nor, in fact, any material, no matter how toxic, which is not safe if given in sufficiently small doses.
Mr. Yannacone: Oh, really?
Dr. Hayes: This is the way that toxicologists find this thing. Now it's in total disagreement with the lay understanding. The lay understanding is that there are toxic materials and then there are safe materials. It turns out that either one can be shifted depending on the dosage. And so the way of finding whether the material is safe is first to test it in animals. . . .

Yannacone didn't like this answer and moved to have it struck from the record as unresponsive, which started another round of legal squabbling. When this squabble was squabbled out, Yannacone took up the validity of Hayes's research and began asking him if he had performed various medical tests on his volunteers and factory workers in an attempt to get Hayes to admit that his studies would only recognize gross neurological or clinical symptoms. However, Yannacone could never trap Hayes into making a flat admission of this, though subsequent cross-examination seemed to point strongly in that direction.

In conjunction with this line of attack, Yannacone next began what was to be his cutest trick at the Madison hearings. Picking up a medical manual, he began reading possible tests for blood abnormalities, asking whether each had been performed. It proved both confusing and embarrassing for Hayes.

Q: Did you measure hemoglobin?
A: Yes, we did.
Q: Did you determine the hematocrit?
A: Yes, sir.
Q: Did you determine the erythrocyte sedimentation rate?
A: I think we did. . . .
Q: Did you determine the amount of C-reactive protein?
A: No, we certainly did not.
Q: Did you determine whether or not there were any sickle cells?
A: Yes, this would have shown up in the differential count. . . .
Q: Did you determine the mean corpuscular volume?
A: I don't think this was specifically measured. . . .
Q: Did you determine the mean corpuscular hemoglobin?
A: Again, I don't think this was expressed. . . .
Q: Did you determine the coagulation time?
A: No, sir, I don't believe so.
Q: Did you determine the clot retraction time?
A: No, but you see, the people had no---
Q: Just answer my questions. You can elaborate a little bit later. Did you determine the bleeding time?
A: No, sir.
Q: Did you determine the fragility of red blood cells?
A: No, sir.
Q: Did you do any blood grouping?
A: Why, of course not. It has nothing whatever to do with this subject.
Q: We will get to whether it does or does not in a moment. Did you make Coomb's test?
A: No, sir.
Q: Did you take any blood cultures?
A: No, there was no indication for blood cultures.
Q: All right, just yes or no and [when] we get to the end, sum it all up. Did you determine the blood sugar level?
A: In one study, yes, we measured sugar and found no abnormality. . . .
Q: Did you determine the plasmic prothrombin time?
A: No, sir.

And so the questions continued, to the delight of the pro-petitioner hearing room audience and the chagrin of "No, sir" Hayes and the Task Force lawyers.

After exhausting the manual, Yannacone began questioning Hayes as to exactly what his studies determined about the health of the "victims."

Q: . . . In determining the condition of the volunteers at the beginning of the experiment the only things reported were the ages, the weights, the red blood counts, the hemoglobin level, the white blood cell counts, the polymorphonuclear . . . leukocytes, heart rate at rest, heart rate at exercise and at rest, the systolic blood pressure, the pulse pressure at rest, the systolic blood pressure at exercise, pulse pressure at exercise, the plasma cholinesterase, and the DDT and DDE stored in the fat. Is that a complete statement of the examination tests performed on the volunteers at the beginning?
A: No, there were some other studies which---
Q: Were they reported?
Mr. Stafford: Let him finish his answer.
A: I don't really know. We also tried to follow up as new findings came out. . . .

The probing continued:

Q: All right. Now, Doctor, back in 1956 I think it was when you said you did these studies, did you have a particular experimental reason for conducting them?
A: Yes, we certainly did, and the others too. We were interested in finding a high [DDT] level that was safe. And we estimated that the one we tested would be safe. We were also interested in studying [DDT] storage in relation to dosage and, if possible, excretion. Certain improvements in the method were developed during the first study and carried out in much greater detail in the second, with literally thousands of chemical analyses on urine in the second study.
Q: Those were your experimental reasons?
A: Those were the reasons.
Q: To study storage and excretion of DDT and its metabolites in humans, right?
A: That's correct.
Q: And those experimental objectives were reached by tests of the various excretory products of the human subject, weren't they?
A: As well as we could with those methods.
Q: And you made some determinations of the level of storage and excretion, right?
A: Yes, sir. . . .
Q: All the other medical testing was peripheral, wasn't it?
A: Why, no, we were looking for any possible effect, with emphasis on those that had been seen both in man and in animals as a result of exposure to this compound.

Q: Well, what was the purpose of the studies now, to determine and measure the excretion and storage of DDT and its metabolites?
A: And to see if we could in fact find any effect from the particular dosages that we had chosen to use.
Q: Any effect, or only certain effects?
A: Well, we were looking for any effect. But the tests emphasized those that had some chance of being positive as indicated by what was known.
Q: At that time?
A: At that time.
Q: In other words then, Doctor, your tests were somewhat predetermined by your expectation of what might occur from what you knew at that time?
A: I believe this is characteristic of all tests; they're designed in terms of what is known.

Yannacone's response to this was merely and cynically, "Oh?"

Then after a series of questions on the circumstances of the experimentation done on prisoners by Hayes in the 1950's, Yannacone threw out a very significant query.

Q: Now, Doctor, at that time was any attempt made to measure the enzymatic functions of the liver?
A: . . . In answer to that question, I think your answer is no. We actually planned before I retired from the service—and the work will go forward—studies of drug metabolism in people with heavy exposure to DDT. . . . It has, in fact, been done in Sweden, and this reveals an effect which not only we but I believe no one was prepared to look for at the time this first study was made.

In the light of the testimony of witnesses for the petitioners on the hepatic enzymatic-inducing activities of DDT and its metabolites, this was an important admission of omission.

Yannacone then began questioning the statistical methods of analysis used by Hayes in his work, first impugning his knowledge of statistical methodology; then stating that Hayes, because of the crude nature of his analyses, might have omitted significant items from his published papers; and finally zeroing in on his use of the t-test* as a primary statistical tool for the analysis of data, stating that its measurements weren't sufficiently sensitive. To illustrate this, Yannacone began a line of attack, memorable to all and infuriating to the pro-DDT forces.

Q: Doctor, in the course of your medical studies did you ever have occasion to hear about the substance commonly referred to as testosterone?

*a statistical test used to compare the mathematical means of normal populations which have unknown standard deviations

A: Yes.
Q: Are you married, Doctor?
A: Yes, sir.
Q: Got any children, Doctor?
A: Yes, sir.
Q: Have you got any idea what the current levels, blood levels, of testosterone in your system were about the time you were fathering those children?
A: No, sir, I haven't the faintest notion; but they were adequate.
Q: Do you know how little difference there is, Doctor, between "adequate" and "inadequate"?
A: No, sir, I don't. . . .
Q: Doctor, I want you to assume that the working level of testosterone sufficient to maintain your male functioning is something on the order of five parts per billion, and that [a] level below two parts per billion is sufficient to get rid of your mustache, the hair on your chest, the hair on a number of other places, raise your voice a few notches, and probably preclude your fathering anything other than freak shows. Now, Doctor, assuming that difference, I want you to sit there and—if you want to use pencil and paper you may—make the calculation of the level of difference between two parts per billion—that's two times ten to the minus ninth—and five parts per billion—which is five times ten to the minus ninth. Now, if my arithmetic is correct—and you may check me with pencil and paper—that difference is three times ten to the minus ninth, or three parts in a billion parts.

Now, Doctor, can you now tell us that the student's t-test is sufficient to measure those kinds of differences in living populations? Yes or no?

Another legal battle erupted over this question, but the question itself was enough to inflict damage on Hayes and didn't need an answer.

Shortly after this exchange, the witness was excused from the stand in order to accommodate Harry Hays. Wayland Hayes was recalled two days later, and Yannacone began questioning him again on the subclinical effects of DDT, especially those related to enzyme induction.

In answering Yannacone's questions, Hayes returned to old ground: the search for overt neurological signs as symptoms of DDT poisoning. And agile Yannacone just as quickly returned to his argument that the neurological studies that Hayes and his colleagues had conducted were insufficient.

Mr. Yannacone: Were any procedures utilized to determine the subclinical effects of enzyme induction?
Dr. Hayes: No, this was not done. What we did, for example, . . . in the neurological examination we went through [was] this. One

of the most sensitive tests for the effects of DDT is tremor. It is entirely possible that a person might have tremor, from whatever cause, without realizing it, without thinking of himself as ill and without being inconvenienced. We examined these men, for example, for tremor. . . .

Q: What tests did you employ to determine whether there was tremor?

A: Just the usual test of having . . . the man extend his hands, and to look at them and see if there was tremor. . . .

Q: You were not looking for tremors which would require determination by more sophisticated tests, were you, Doctor?

Yannacone then went back to the subject of the liver and microsomal enzyme induction. Hayes agreed that such induction occurred, but denied that any data was available which showed that the induction of enzymes by DDT was harmful, backing up this assertion with a detailed description of liver function. After this, Yannacone changed course, returned to the nervous system, and began questioning Hayes about the effects of DDT on nerves themselves.

Q: Doctor, do you know, or can you tell us what you believe is the mechanism of action of DDT on the nervous system?

A: Neither I nor anyone else know the mechanism of action of DDT on the nervous system on a biochemical level. . . .

This answer was to be rebutted, at least in part, later on in the hearing by Dr. Alan Steinbach, a neurophysiologist, then teaching at Albert Einstein College of Medicine who was to be one of the most persuasive of all the petitioners' witnesses.

But Yannacone was far from finished with Hayes. In the midst of what often appeared to be merely repetitious questions, Yannacone would throw in a bombshell. For example, during the answer to one of Yannacone's questions, Hayes stated that damage to a single cell was not significant to the human body. Yannacone pounced.

Q: Doctor, is it your opinion today, sitting here as an M.D. and a professor, in 1969, that it is possible to damage even a single gene of a human chromosome in a human egg or sperm cell and not run the risk of producing serious damage, ultimately, to the organism that might survive birth?

Hayes's answer was that usually damage to a sperm cell or egg cell produced sterility, but Yannacone had made his point and made it well. He continued.

Q: Doctor, I'm not interested in sterility. I'm interested in *mutagenesis*. Have any studies to your knowledge been done on whether

or not DDT has any mutagenic effects whatsoever on any organism?

A: . . . These studies have been made, and they have been negative, to my knowledge.

However, later on that year, information was released which strongly indicated that DDT was not only mutagenic but *carcinogenic* as well, and this information ostensibly led the federal government to make the long-delayed ban on DDT.

Yannacone then moved back to the area of human diseases such as rheumatoid arthritis and heart disease, not easily detectable in their early stages, attempting to show that DDT, too, was possibly having effects that were not yet seen; and from there to the work of Dr. William Deichmann. This Florida toxicologist had performed a series of autopsies on people who had died of terminal diseases and had discovered that their bodies contained significantly higher concentrations of DDT and its metabolites than normally found in healthy individuals.

Q: Doctor, Dr. Deichmann reported,* did he not, that in individuals who died of various terminal diseases, total DDT in body fat was found to be elevated twice, two and a half times in arteriosclerosis, leukemia, carcinoma, hypertension, and encephalomacia? . . .

A: Yes, he did. And as I have already pointed out, his conclusion was that he could draw no conclusion about the relation of causation from data at hand. . . .

Yannacone then caustically asked:

Q: Doctor, you are telling us, are you not, that Dr. Deichmann's proper scientific statement that he cannot positively relate these findings to the level of DDT and say that DDT is the absolute direct single cause thereof, is equivalent to your statement that you can now sit in 1969 in that witness chair and tell us in the face of Dr. Deichmann's paper that you are a hundred per cent medically sure that DDT is absolutely safe? Doctor, is that what you are telling this hearing?

A: Yes, sir, this doesn't interfere whatever with reaching that conclusion. . . .

Q: And you still feel in spite of [Deichmann's data]—and it's 1969 data—you are still sure that DDT is a hundred per cent safe, is that what you are telling us?

A: That's correct.

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*J. L. Radomski, W. B. Diechmann, and E. E. Clizer, "Pesticide concentrations in the liver, brain and adipose tissue of terminal hospital patients," *Food and Cosmetics Toxicology* 6 (1968): 209–20.

Yannacone had one more important thing to bring out with Hayes, suggested to him by Dr. Goran Lofroth of Sweden on his arrival in Madison. This was a matter discussed at the Swedish conference which had taken place during the Madison hearing recess and had led to the banning of DDT in that country.

Q: Now with respect to the Laws study,* there weren't any women involved in that study, were there?
A: No, sir.
Q: There weren't any infants involved in that study, were there?
A: No, sir.

Yannacone asked Hayes the same question about the other studies on which he had based his testimony.

Q: Now, Doctor, there were no infants or children in that occupational study or in your convict study, were there?
A: No, sir.

After this, it got emotionally hectic again in the hearing room but Yannacone had made his point: the efficiency of liver detoxification mechanisms might vary with age and sex, yet all of Hayes's opinions were predicated on data from adult males.

But Hayes still stuck with his opinion that DDT was safe.

Yannacone's brutal cross-examination of Wayland Hayes was but a single technique among the tactics used to discredit the DDT industry's toxicologist and to establish the potential danger of DDT to humans. As the parade of witnesses continued—Richard M. Welch, biochemical pharmacologist from Burroughs Welcome and Company; Theodore L. Goodfriend of the University of Wisconsin School of Medicine; Goran Lofroth of the Royal University of Stockholm; and Alan Steinbach of the Albert Einstein School of Medicine—other tactics appeared.

Welch, who had testified before the recess, had been given the job of carrying the story of the enzyme-inducing qualities and hormone-like effects of DDT to a species more physiologically akin to man, the rat. By introducing this research on higher mammals, Yannacone hoped at least to lessen the impact of Hayes's scene-stealing human work.

Dr. Welch: . . . We initially studied the effects of chlordane . . . and DDT on the metabolism of testosterone in . . . rats. Now testosterone is a naturally occurring *androgen* that's present in man

*E. R. Laws, Jr., A. Curley, and F. J. Biros, "Men with intensive occupational exposure to DDT," *Archives of Environmental Health* 15 (1967): 766–75. This study was conducted on men working in DDT manufacture at the Montrose Chemical Company and was the basis of much of Dr. Hayes's testimony.

and in rodents. We found that upon the daily administration of DDT or chlordane there was a marked increase in the rate or the metabolism of several steroids* by liver enzymes in the rat. . . .

Several drugs and insecticides belong to a group of compounds now generally recognized to be enzyme-inducing agents, that is, they will cause an elevation in the enzyme level in the particle of the liver called the microsome. These enzymes are collectively called a mixed function oxidase system with a broad spectrum of activity, that is, they are rather nonspecific in that they metabolize, in addition to steroids, very many drugs and foreign compounds. When one administers a compound that causes an elevation in these enzymes, it is referred to as an enzyme-inducing compound.

Well, further studies with DDT and chlordane revealed that, with respect to testosterone metabolism, we got marked changes in the degree of hydroxylation of testosterone. . . . [Also,] the ability of DDT administration in vivo to stimulate the metabolism of estradiol in vitro by these liver enzymes suggested that these insecticides might decrease the biological activity of estrogen in animals. Now in vivo ---

Examiner Van Susteren: Before you go any further, while probably most of those in this room understand what you mean by "in vivo" and "in vitro," would you explain for the record what is meant by both terms.

Dr. Welch: "In vitro" means the addition of something into a test tube, [the addition] takes place outside of the body; while "in vivo" is occurring within the animal.

Now, as I just said, indicating that the ability of DDT to alter the metabolism of estradiol and other steroids in vitro suggested that perhaps there was an alteration of enzyme activity and a decrease in biological activity in vivo.

We proceeded to investigate several insecticides. And we have found that indeed something like chlordane will cause a marked decrease in the action of estradiol in vivo. . . .

When we proceeded to do the same type of thing with DDT, because DDT was active in vitro, we found some rather interesting results. We found we couldn't do the experiment in the animal because DDT had some action on the uterus itself. . . .

We noticed upon the injection of DDT we got a marked increase in the uterine wet weight at six hours after the administration of DDT. This effect suggested to us that perhaps DDT itself did possess some estrogenic activity, that is, it acted in some capacity like the natural hormone estradiol would act.

Examiner Van Susteren: Well now the Examiner is getting curious as to what type of a test subject you did your work on.

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*among them, testosterone

Dr. Welch: We studied immature female rats, for good reason. Immature female rats would not be able to make any estradiol of their own and therefore would serve as a good test system for evaluating estrogenic compounds. . . . In addition, we have demonstrated this [increase in uterine wet weight] to take place in adult ovariectomized rats where the level of estradiol is low. . . .

Examiner Van Susteren: And by "ovariectomized" you mean where the ovary was removed?

A: That's right. The ovary would complicate this enzyme system, because it would make estradiol and influence the uterus. And since we were trying to evaluate the effects of DDT alone on the uterus, it was necessary to remove that organ which was responsible for the endogenous synthesis, that is, in vivo, of estradiol. . . .

Now, an increase in the uterine wet weight is not the sole criteria for determining whether a substance does possess estrogenic activity. There are many biochemical events that take place in the uterus following the administration of an estrogen, and we proceeded to explore some of these.

What generally happens is that there is an increase in the incorporation of *glucose* into uterine lipid-protein *ribonucleic acid* and in the acid-soluble constituents of a rat uterus following an [injection of] estrogen. Since this is known to take place, we investigated the effects of DDT on these biochemical parameters. And, indeed, we did find that DDT did cause an increase in the incorporation of uniformly labeled glucose into these various fractions of the rat uterus.

Further studies from our laboratory indicated that DDT, . . . having estrogenic properties, would indeed compete with estradiol for receptor sites on the uterus, that is, [DDT compounds] would prevent the combination of estradiol with a receptor site on the uterus virtually because they themselves would occupy that receptor site. . . .

Mr. Yannacone: Now, Dr. Welch, in the course of your research, what is the smallest amount of DDT that you found produces estrogenic activity?

A: . . . The administration of a single dose of five milligrams per kilogram of DDT (tech) caused a statistically significant increase in the uterine wet weight; while the administration of one milligram per kilogram of the o, para-prime DDT analog caused a significant increase in the uterine wet weight.

Those are the lowest levels that cause the effect. . . .

. . . We have not done a dose response curve on how little DDT is necessary to cause changes in the liver enzymes of rats. However, there is adequate literature on this aspect of it. . . .

After the usual argument over whether scientific literature could be introduced into the record, Dr. Welch continued.

Dr. Welch: In determining . . . what level of DDT can cause biochemical changes in the liver of rats, I indicated . . . that in a publication submitted by Hart and Fouts in *Toxicology and Applied Pharmacology*, Volume 5 in 1963, they found that five parts per million of DDT when given to rats for three months caused an increase in the activity of enzymes in the rat liver.

Welch then cited another source which stated that the DDT level could be reduced to 1 part per million of DDT, and a final source stating a level as low as 40 micrograms administered for four weeks would be effective.

Mr. Yannacone: Now Doctor, would you summarize for us briefly what conclusions you have drawn with a reasonable degree of scientific certainty in your professional capacity as a biochemical pharmacologist with reference to your work and the other work that you have described here, in particular relating the effects of DDT on biochemical and biological systems?

A: Well, the exact relevance requires more study. . . . But in a publication by Swabe* in Germany they have indicated that a fat residue of DDT of 10 parts per million in rats causes a change in the pharmacologic action of pentobarbital, a commonly used drug in man; and they have indicated that this change in pharmacologic activity is correlated with an increase in the ability of the liver of the rats to metabolize pentobarbital. . . .

Examiner Van Susteren: It inhibits the pharmacologic activity?

A: Right, because it shortens the duration of action of pentobarbital. The explanation for this is that this amount of DDT increased the enzyme level in the liver of the rats responsible for the breakdown of this drug.

Now this 10 parts per million is within the range of DDT found in human fat. . . . Thus, if one can extrapolate data from animals to man then one would say that a change in these enzymes probably does occur in man. . . .

Bringing rats even closer to humans, at the end of Welch's direct testimony Yannacone asked:

Mr. Yannacone: Now Doctor, the steroid hormones testosterone, estradiol, [and] estrone that you described in your work, these were found in rats, were they not? . . .

A: Testosterone and estradiol and hydrocortisone are known to be present in the rat.

*Swabe, "DDT—Speicherung bei der Haltung Von Veruchstiern alsmogliche Fehlerguelle bei Arzneimittel—prufungen" *Arzneimittel-Forsch* 19 (1964): 1265.

Q: All right, now the substances that you described as being present, these substances that you found in the rats, they are no different than the same named substances found in other mammals like humans, are they?
A: That's right.
Q: And for this reason, rats are commonly chosen as laboratory animals, are they not?
A: That's right.
Q: All right. In other words, the testosterone you found in a rat is the same as the testosterone you find in a human?
A: Yes.
Q: The estradiol you find in a rat is exactly the same as the estradiol you find in a human, is that right?
A: That's right.
Mr. Yannacone: Okay Doctor, thank you very, very much. I have no further questions.

With S. Goran Lofroth, Yannacone's strategy was much more devious. Lofroth was a top European environmental scientist: he had been Chairman of the Working Group of Environmental Toxicology, a committee appointed and funded by the Swedish Natural Science Research Council to make an exhaustive search of the literature on man's burden of DDT compounds and the effects of those compounds on other mammals. In addition, Lofroth had participated in the Swedish conference which had led directly to the banning of DDT in that country. A crucial fact here was that Wayland Hayes, too, had been at that hearing and by all accounts had "lost," a fact which had not made the American press and one that Yannacone was most anxious to introduce. With this background, Lofroth should have been one of Yannacone's strongest witnesses; the fact that he wasn't and the reasons for that fact, form one of the more bizarre stories of the Madison hearing.

Lofroth, rather than appearing as Yannacone's witness, took the stand as the "impartial" witness of Robert McConnell, the Public Intervenor. Now, McConnell's position was a curious one, very much analogous to that of a Swedish ombudsman. He represented the public's interest in matters directly concerning them where they would otherwise have no representation. Officially, McConnell was objective in the matter of DDT's innocence or guilt.

After establishing Lofroth's academic qualifications, McConnell in one motion immediately attempted to introduce as exhibits the 56 scientific papers that Lofroth had brought with him from Sweden to serve as a basis for his scientific opinion. This attempt failed because of repeated objections by Stafford to their admissibility. Nonetheless, led by McConnell, Lofroth grimly continued. He began by giving a summary of the average concentrations of DDT found in man, con-

cluding with the statement "the average concentration in the human adipose tissue in the whole world—[and] this is just the average of the whole world population—seems to be in the range of 10 to 15 ppm." Lofroth then carried his survey to the concentrations of DDT compounds found in human milk. As historical background, he cited an early report by Woodard published in *Science* in 1945 stating that in experiments with dogs, ingested DDT is indeed excreted in milk. From that early finding Lofroth continued on to reports by Lang et al. on the presence of DDT in human milk; to a report in the *British Medical Journal,* 1965, that the sum of the DDT compounds in the human milk of 19 sample subjects averaged .128 ppm; to a report by Quinby et al. published in *Nature* in 1965 stating an average figure of .17 ppm for subjects in the U.S.; to further findings in the Soviet Union.

At this point the cold war, supposed in most quarters to be an issue of the 1950's, popped in with Stafford's objection:

Mr. Stafford: Your Honor, reluctantly I'm going to expand my original objection and ask that the witness be instructed to make no reference whatsoever to DDT and its metabolite residues in the Soviet Union, China, or any of the iron curtain countries without first presenting in this record a full foundation as to the accuracy of these residues, how they were taken, and how the DDT presumably was manufactured in these countries. . . .

The objection was overruled, to the laughter of most of those in the hearing room who were hoping for better East-West relations; and Lofroth proceeded, still without the benefit of his supporting documents, to give the opinion that was a high-point of the petitioners' case.

Dr. Lofroth: One arrives at the conclusion that the average concentration of DDT compounds in human milk is about .1 to .2 ppm. The average daily intake of human milk of a breast fed baby is about 150 grams milk per kilogram body weight. Easy calculation means that the daily intake of DDT compounds is about . . . .02 milligrams DDT compounds for the average baby.

The World Health Organization and Food and Agriculture Organization of the United Nations make, jointly, recommendations about acceptable daily intakes of pesticides for man. For DDT compounds, that is DDT plus DDE plus DDD, this is .01 milligram per day [per] kilogram body weight.

Incidentally, this DDT plus DDE plus DDD are what are generally called DDT compounds.

Thus breast fed children ingest about twice as much DDT compounds as the recommended daily maximum intake. Of

Before it is shown that DDT compounds are safe for man, shown with a significant degree of scientific certainty, one should not further spread DDT in the environment.
S. Goran Lofroth

course, this is the average and some ingest less and some ingest more.

My opinion is that from these last two statements it is obvious that many breast fed children ingest more than this recommended maximum daily intake.

Furthermore, it is in the range of exposure to which laboratory animals show pharmacodynamical changes. What these changes mean is not known, [so] one cannot predict the consequences with similar or other changes at work in man, and one does not know what the future might bear for mankind.

Thus, before it is shown that DDT compounds are safe for man, shown with a significant scientific certainty, one should not further spread DDT in the environment. . . .

Mr. Stafford: While there's a moment here, I wish to move the witness' testimony regarding safety to mankind or to babies . . . be stricken. . . . There's been absolutely no foundation in his background to qualify him to state an opinion in this regard.

Examiner Van Susteren: Just a moment. He merely used the information that he cited and that he read, and the studies, incidents thereto in the formulation of his opinion.

Mr. Stafford: He has no independent opinion, then, I presume?

Examiner Van Susteren: He has rendered his opinion.

The admissibility of Lofroth's documents was not the only problem to plague his testimony. Soon arguments arose as to whose witness Lofroth actually was, Stafford claiming that, since Lofroth's transportation expenses had been paid by the Environmental Defense Fund, he was, in fact, Yannacone's witness; and Van Susteren seeming genuinely confused by the whole situation. The court record, reminiscent of Pope's famous couplet:

> I am his highness' dog at Kew
> Pray tell me, sir, whose dog are you?

contained ample evidence of this time-consuming battle in its 145 pages, but recorded particularly bitter arguments when Yannacone tried to "cross-examine" the witness. Naturally, Stafford insisted that Yannacone was not cross-examining at all, but instead, was merely continuing McConnell's attempts to get Lofroth's disputed documents on the record—and, indeed, Yannacone did introduce the 13 most important ones.

Mr. Stafford: Now what's happened is that Mr. McConnell called his witness, had some difficulty qualifying him, as I think is clear in this record, and asked him some opinions, and he rendered some. Clearly Counsel for the petitioner has a right to cross-examine this witness, and that examination must be restricted to the witness' direct examination. I'm objecting because, of course, what's happening here is that the petitioner is attempting to shore up the rather gaping holes of these denied judgments. . . . Now this is not cross-examination; it's a transparent device to give Counsel two kicks at the cat now, and this is improper.

The various Lofroth battles culminated during Stafford's final examination of the witness, an examination which, at last, gave Lofroth the opportunity to make a significant point, but also gave Yannacone the opportunity to enact one of his most amusing scenes.

Mr. Stafford: When was DDT first generally used in the world, if you know?

Dr. Lofroth: 1942. . . .

Q: And there've been approximately 27 years go by now. Do you agree that as far as human children are concerned, sufficient time now has gone by so that at least two generations of human children could be affected by the DDT in diet or atmosphere?

A: No. . . . The large scale use started a little later than that so my opinion is that the majority of the population has yet only been exposed to DDT, say, something between 20 and 25 years. . . . No one above this age was exposed to DDT in the very young age at the time when they are sensitive to poisons, that is, at the

stage when the liver hasn't developed the [de]toxification mechanism. . . .

Q: Yes, well, there are many, many breast fed babies who were exposed to DDT at the breast of their mothers, many years ago who are now adults, are there not, in the human population? . . .

A: There must be.

Q: Why, of course. Now do you know of any instance or episode where these children . . . have been harmfully affected by DDT from their diet or from the environment? . . .

A: *To my knowledge there has been no investigation on the thing even. That's even worse.**

Shortly thereafter Yannacone raised an objection to a line of questions used by Stafford. Examiner Van Susteren responded to his objection by saying:

Examiner Van Susteren: All right, now just a moment. The Examiner wants to point something out here. He stated yesterday and this morning that he had serious and grave doubts as to whose witness Dr. Lofroth was. If you had cross-examination this morning, are you trying to make him your witness now? . . . It's becoming increasingly obvious today that Dr. Lofroth appears to be not only Mr. McConnell's witness but yours.

Mr. Yannacone: Mr. Examiner, I object to that.

Examiner Van Susteren: Any differentiation between cross-examination and direct examination here turns into a farce. Now gentlemen---

Mr. Yannacone: Mr. Examiner---

Examiner Van Susteren: Let's get on with this.

Mr. Yannacone: For the record, let the record show I leave the room now for the balance of the examination of Dr. Lofroth. He is Mr. McConnell's witness and I am sure that if the Examiner will let him answer the questions, he can answer any question Mr. Stafford might like.

Mr. Stafford: Good bye.

—Or almost "good bye." Yannacone simply couldn't resist popping in once more, occasioning a closing quip from Examiner Van Susteren:

Examiner Van Susteren: The record may show that, while Mr. Yannacone was absent during the examination of Mr. Stafford and Mr. McCallum [another Industry lawyer] he has his trusty tape recorder in front of him and that the tape recorder was watched by the Examiner and never once stopped.

*italics, editorial

Throughout the DDT litigation, Yannacone had been pressing for a neurophysiologist to testify about DDT and its effect on the nervous system. Wurster and others, however, insisted that no data from neurophysiology with all its sophisticated mathematics was needed; that the whole case could be based on the story of thin egg shells and calcium metabolism in birds. But Yannacone kept saying, although "bird nerves and people nerves are essentially the same, people don't lay eggs with shells."

So Alan Burr Steinbach, a 28-year-old neurophysiologist at the Albert Einstein Medical School was found, one of a "new breed" of scientist increasingly evident, equally at home discussing science or the situation in the urban ghettos. Here was a witness who could break the backbone of the DDT Task Force contention that the petitioners could present no data that was really relevant to man for, by the time Steinbach was through testifying, everyone in the hearing room had a basic understanding, not only of the effects of DDT on nerves, but of a possible physiological basis for the tremors George Wallace had observed in birds and of the history of neurology as well.

In many ways, Steinbach was the most impressive witness that the petitioners corralled. He managed to take the subject of neurophysiology, one alien to most people in the hearing room, and make it relevant to their lives and to the contaminants in their environment.

Mr. Yannacone: Now, Doctor, in the regular course of your professional activities, have you had occasion to investigate the effects of DDT on the nervous system?

Dr. Steinbach: Yes.

Q: Now, Doctor, before we come to the opinions, conclusions, and whatnot, would you briefly outline for the record the mechanism of nerve conduction?

A: I think that in order to explain it fully, it would be well to give a small historical background, if it would be all right.

Q: Go ahead.

A: Basically the place to start is way back at the beginning with Galvani, [in] 1786, who discovered what he called animal electricity; that is, that a frog or other animal, if you touch the nerve to a piece of metal or even touch the nerve to another frog, you could get a contracton in the muscle fiber. Galvani developed a theory based on the idea that the nerve was a tube with a surrounding insulating layer and a sort of fluid internal layer, and that the fluid internal layer in some way carried what he called at that time "electrons," although that is not the same as the present term electrons, . . . and that somehow as a result of the flow of electrons down the nerve, one induced a contraction in the muscle fiber.

This was immediately taken up and seized on by Volta, who was at that point rather high up in the Academy of Sciences, and

it was probably the first case of a well-meaning but perhaps academically not too qualified scientist being squashed by a superior position, but not superior reasoning. In any case, Volta successfully discredited Galvani and it wasn't until about, say, 1840, that Galvani's ideas were proved to be substantially correct.

Steinbach then took his audience through the nineteenth-century world of science, tying in Matteuchi's experiment showing that a healthy nerve has more electrical potential than an injured one; Michael Faraday's mathematical calculations that led to the invention of the galvanometer, the instrument which measures the extent of electrical current flow in the nerve; and Golgi's efforts to prove the existence of junctions between cells.

After tracing the history of neurology into the twentieth century, including the experiments which led to the determination of how long it takes for a nerve impulse to pass along a nerve, how strong that impulse is, and how the electrical impulse is generated, Steinbach laid the groundwork for introducing the Hodgkin-Huxley equation, the mathematical formulation that was to be the basis of his substantive testimony. Yannacone, who is enamored of technology and its terminology and electronic gadgetry had Steinbach go into minute detail in describing the methods and modes of deriving this equation, introducing into the record fourteen pages of complex mathematical testimony, incomprehensible in all but general outline to most of those present. Finally, in summary, Steinbach said:

Dr. Steinbach: In order to check the accuracy of our description of the ionic process [which occurs within a nerve we] should be able to use this [Hodgkin-Huxley] equation with the constants, and mathematically generate a time-variant function, that is, an action potential which will match exactly the action potentials that one actually records in the nerve. And this was the successful test of the Hodgkin-Huxley equation, . . . that they were in effect able to successfully match the performance of the nerve with a solution of an equation generated from their description of the process. . . . What one has in sum-up of this is an empirical description of the way in which the nerve functions. One has perhaps the most sophisticated tool for the investigation of neurophysiological and neurological processes that could have been hoped for considering the instruments available at this time. . . .

With this analytical tool, since 1952, neurophysiologists have proceeded to attempt to investigate the mechanism of action of various chemicals that have been thought in the past to interfere with nervous system function.

So, at last, DDT entered the picture.

Mr. Yannacone: Doctor, in the course of your regular professional activities have you had occasion to investigate the effects of DDT upon the nervous system?

A: Yes, I have.

Yannacone then threw in a few qualifying questions before getting down to the business at hand.

Q: Now, Doctor, can you—just yes or no—can you form an opinion with a reasonable degree of scientific certainty as to whether or not DDT has any effect on the nervous system?

A: Yes.

Q: Doctor, does DDT have any effect on the nervous system?

A: Yes.

Q: Doctor, can you describe for us the mechanism of action of DDT upon the mammalian nervous system with respect to [its] conductance mechanisms? . . .

A: DDT was examined on various invertebrate nervous systems starting in 1946. . . . The experiments basically were done, first with the cockroach and then with crustaceans. The observations were quite definite that DDT did have an effect.

In the case of the cockroach (the insect), and the crustacean, the effects occurred at very low concentrations. The effects were variable. In most cases in the cockroach, it consisted of repetitive firing in the nerves, where one impulse applied to the nerve no longer evoked a single message going down the nerve, but rather a large volley of messages. The behavior of the cockroach, at the same time, showed disorientation, running about, tremoring, kicking of legs in the air, and death. The idea was the DDT, causing repetitive firing, jammed all the transmission lines, overworked the cockroach, and caused death due to exhaustion.

In the case of the crustacean, repetitive firing wasn't so much an aspect. Instead, one saw a change in the afterpotential following the nerve impulse. Based on the formulation in the Hodgkin-Huxley equation, the afterpotential is due in part to the turning on of the potassium conductance and in part to the slowness of the turning off of the sodium conductance. . . .

And then a little later:

Dr. Steinbach: DDT [is] in a class by itself as far as nerve active agents are concerned, in that I have never heard anyone state with confidence they felt there was a lower limit to the effect or a threshold concentration.

Steinbach then stated what was to be the most significant part of his testimony:

Dr. Steinbach: DDT, once applied, doesn't come off within the time course of the experiment. And by that I mean a matter of hours . . . because that was as long as we kept [these experiments going]. This makes it different from any other of the so-called low molecular weight toxins that I know of. Snake venoms, of course, chewing up the membrane, do effectively irreversibly damage it. But the other toxins, curare, veratrine from belladonna, tetrodotoxin from the puffer fish, saxitoxin from the clams, scorpion venoms, black widow spider toxins, are all reversible to some extent. The local anesthetics are reversible. DDT, as far as our experiments were concerned, was not reversible. . . .

A prolongation of the active state of the nerve means—coupled with no change in the inactivation process for sodium—that after one nerve impulse, when the channels become ready to conduct or to open again to conduct a second impulse and examine or test the potential across the membrane, they will find that, according to the potential, they should already go again. That is, no further impulse would be necessary to make [the nerve] fire another signal. This could produce repetitive firing. On the other hand, in other nerves where sodium inactivation takes a longer time, one could simply find that the nerve, on reactivating its sodium mechanism, finds that the potential is already too high to fire . . . and instead [the nerve] would merely remain quiescent. This would produce complete failure of the transmission line or at least intermittent failure. Either of these mechanisms quite clearly and very conclusively could cause tremors and could cause grave disturbances in terms of the ability of the animal to move or to make motions.

I think that the connection between these two is not all a matter of a far-flung difficult connection to make, but a question of saying: Can the . . . data account for the observed biological effects? Yes. Does it prove that they are caused by that? No. But that it can account for it is unequivocally true.

I really think that the observations outlined by Dr. Wallace both today and in his earlier papers, when no one else was interested in this (the effects in animal populations), could definitely be accounted for simply on the basis of the known mechanism of action of DDT on the nerve.

Shortly thereafter, Yannacone asked Steinbach the big question:

Q: Now, Doctor, will you proceed with your opinion as to whether or not DDT can exert sublethal or subclinical effects on the nervous sytem?

A: . . . One does not voltage clamp human beings' nerve fibers for the simple reason [that] they are too small. There's another reason for that, too. Most humans don't like to have their nerve fibers

taken out. But that in every respect in terms of conduction velocity, in terms of the dependence on temperature, in terms of the toxicology, and every other respect, differences in terms of chemicals that act such as the ones I have described should not be great between, say, higher mammals [such as man] and amphibians. One might expect more differences between crustaceans and amphibians, but it turns out there don't seem to be as many as one would have thought from actual experimental data in this case. . . .

In terms of the sublethal doses, I think that there are several important points about DDT's action. One is that [DDT] . . . apparently acts—well, for our experiments, irreversibly. I can't say, you know, whether it ever is reversible. Conceivably it might [be]. But we had no indication it [is]. It certainly acts for a long time. Presumably this is because of the high lipid solubility.

Second is that in terms of the actual effect, the change in the turning off phase of the sodium, that this is the type of a change that very easily would reflect itself to a subnoticeable, not only sublethal effect. That is, one could easily have a buildup in the duration of the action potential short of absolute catastrophe where the nerve would no longer be able to fire action potentials reliably. The problem with this, if it were a one-shot affair where a toxin caused this effect for a short time and then went away, one wouldn't be in trouble. The problem is that DDT seems to have a long term of action, so that this sort of sub—again, not subnoticeable—effect . . . is unique to DDT, I think, among the chemicals I have looked at.

That was the nub of the direct examination of Steinbach. During the cross-examination Stafford emphasized that Steinbach's work was not done on live animals, with the young neurologist pointing out that you can't do this type of experimentation with such subjects. Faced with self-assurance and logic such as this, Stafford gave up the game quickly, leaving Steinbach's testimony as an impressive rebuttal to the gross neurological examinations of Wayland Hayes.

However, there was still a hole in the petitioner's case: with 2664 pages of testimony already on the record, they had yet to find an honest-to-goodness M.D. to refute the good doctor, Wayland Hayes. To fill this hole, the petitioners brought in Theodore Goodfriend, an assistant professor of internal medicine and pharmacology at the University of Wisconsin School of Medicine.

However, the best Yannacone could get from the doctor in the face of Stafford's ubiquitous shouts of "Objection" and "Irrelevant" was an answer to the query:

Q: Doctor, will you give us your opinion as to whether or not it can be determined from the existing state of evidence whether DDT

is absolutely safe to humans at present levels of body burden and exposure?

A: It's my opinion that based on what I have read and my knowledge of what would be acceptable criteria, that one cannot say that DDT is absolutely safe.

Perhaps a tentative note to end on, as had been many sounding throughout the testimony of the four that Yannacone had called to refute Wayland Hayes. Yet, the public could still say, "Yes, there is doubt as to the safety of DDT" and, in the face of, until then, seemingly insurmountable odds, that was enough.