

(The Court recessed from 3:10 p.m. to 3:25 p.m.)

DEFENDANT'S WITNESS, ROBERT GEORGE KALEY, SWORN

DIRECT EXAMINATION

QUESTIONS BY MR. FRUEHWALD:

Q Would you state your name, sir.

A My name is Robert George Kaley, II.

Q Would you spell your last for the reporter?

A K-a-l-e-y.

Q Mr. Kaley, are you currently employed?

A Yes, I am.

Q By whom are you employed?

A Employed by Monsanto Company.

Q Where did you grow up, Mr. Kaley?

A I grew up in South Bend, Indiana.

Q Where did you go to college?

A I went to undergraduate school at Purdue University.

Q What degree did you get there?

A B.S. in chemistry.

Q What postgraduate education have you had?

A I attended the University of Illinois and received a Masters degree in analytical chemistry and also a doctorate in analytical chemistry.

Q Are you a member of any professional associations?

A Yes, I am.

Q What?

1 A I am member of the American Chemical Society, the American
2 Society for Testing of Materials. I am also a member of the
3 American Society for Mass Spectrometry, and a member of several
4 local groups in St. Louis.

5 Q Is that where you currently work is in St. Louis?

6 A Yes, it is.

7 Q What is your current residence address in St. Louis?

8 A 1965 Schoettler, that's S-c-h-o-e-t-t-l-e-r, Schoettler
9 Valley Drive in Chesterfield.

10 Q Mr. Kaley, have you written any articles in your field of
11 analytical chemistry?

12 A Yes, I have.

13 Q Have you written any articles with regard to PCBs?

14 A Yes, I have.

15 Q Can you describe to the jury what articles you have written
16 in that area?

17 A There are approximately four or five articles which have
18 been written over the years. I wrote in about 1975 co-authored
19 with some of my co-employees an article describing the general
20 characteristics of PCBs and how they behave in the laboratory
21 and in the environment.

22 I also wrote a study summarizing some animal feeding
23 studies that we had done and how the PCBs behave when they are
24 being fed to animals and that exposure to the animals is
25 ceased. I wrote, co-authored a paper with a group of other

1 industrial chemists describing the analysis of PCBs in a
2 variety of materials of industrial concern, materials that make
3 the analysis of PCBs very difficult.

4 Q You have mentioned two papers, the first paper on the
5 characterization of PCB, what was the eventual audience for
6 that paper?

7 A That paper was presented at an EPA-sponsored symposium at
8 Chicago, Illinois in 1975. The EPA had gathered together a
9 group of world reknowned scientists actually to describe what
10 was known about PCBs at the time, what various researches were
11 being done on those PCBs, and to discuss options for the
12 management of PCBs.

13 The paper was also presented by me at another EPA
14 conference at a laboratory near Detroit, Michigan about a year
15 later.

16 Q And that last paper you talked about in terms of the --
17 with the other industrial chemists in terms of detecting PCBs
18 and the difficulties?

19 A Yes.

20 Q What was the use of that paper?

21 A That paper was also presented at an EPA-sponsored
22 conference in 1982, I believe. Anyway, sometime during the
23 1980s. That paper was much the same. It was more describing
24 the analytical chemistry of PCB. But the conference was
25 organized for the same reasons that the original conference

1 was, it was to relook at the PCB issue for various worldwide
2 researchers, describe the kind of results they were seeing in
3 their laboratories, and to discuss what the implications were
4 for PCBs in the environment at that time.

5 Q When were you employed by Monsanto Company?

6 A I joined Monsanto in December of 1973.

7 Q And what positions did you hold at that time and
8 thereafter?

9 A Okay. I joined the company as an entry level chemist in
10 1973 as an analytical chemist right out of graduate school;
11 began doing analyses on PCBs immediately on my employ. I
12 joined a group whose primary focus was the analysis of PCBs and
13 investigations of the environmental characteristics of those
14 materials.

15 About two years later I transferred to another associated
16 group where I developed skills in mass spectrometry. In about
17 1979 I was made a group leader of an environmental chemistry
18 group which also had some responsibility for the analysis of
19 PCBs.

20 In 1981 I transferred to our corporate laboratories as a
21 specialist in mass spectrometry.

22 And about 1985 I transferred to our corporate environmental
23 policy staff to work in a more administrative role on
24 environmental problems.

25 Q Has your work with Monsanto and your research given you a

1 familiarity with the physical characteristics of PCBs?

2 A Yes, it has.

3 Q Can you describe for the jury first of all what is a
4 chlorinated biphenyl?

5 A A chlorinated biphenyl is a molecule, a common organic --
6 is based on a common organic molecule which is called biphenyl.
7 It is essentially a double ring structure. Two rings are
8 connected together. After those rings have been connected
9 together, there are ten positions, five on each ring, where a
10 chlorine can be attached to that molecule. And APCB is one of
11 209 possible chemicals that can be formed by attaching one or
12 up to ten chlorines to these two rings that are hooked
13 together.

14 Q Can you give us the terminology of the various subdivisions
15 of PCBs, congeners, isomers, what those things mean?

16 A Some of the language I'll be using gets a little confusing
17 at times. As I mentioned, there are 209 possible PCBs. I will
18 speak of these each as -- each one of these as a congener which
19 is kind of a chemical cousin. They are all related but --
20 there are, in fact, 209 separate compounds that can each of
21 which could be called a PCB.

22 There are several ways of grouping these compounds. And
23 one of the common ways of grouping the compounds is to count
24 the number of chlorines that are on both rings together. So,
25 that if -- we could have one chlorine on the two rings, on

1 either of the rings, we would call that a mono, meaning one,
2 much like mononucleosis means you have one cell in your white
3 blood cells.

4 A monochlorobiphenyl contains one chlorine. We could then
5 go all the way up to ten chlorine and we would have a
6 decachlorobiphenyl. Each of these groupings by the group of
7 chlorines on the molecule is called a congener class or class
8 of similar molecules, the similarity being the number of
9 chlorines on the ring. And these are also often spoken of as
10 homologs which is a term you may have heard.

11 Q Are you aware of the commercial mixtures of PCBs that were
12 produced by Monsanto?

13 A Yes, I am.

14 Q Let me show you what's been marked as Exhibit 5231. Does
15 this chart display some information about the distribution of
16 molecules in various mixtures?

17 A Yes. This chart is kind of an overview chart describing
18 the composition of the various products that Monsanto
19 manufactured and sold as materials. And it is -- we used the
20 term homolog just a minute ago. It talks about the make-up of
21 these Aroclor mixtures by their homologs.

22 MR. FRUEHWALD: Let me stop you there. Let me offer
23 at this time, Your Honor, Exhibit 5231.

24 MR. KARAGANIS: No objection, Your Honor.

25 THE COURT: It will be received.

1 (Defendant's Exhibit No. 5231 received in evidence.)

2 Q Can you see it there, Bob?

3 A Yes.

4 MR. FRUEHWALD: Your Honor, should I move it for you?

5 THE COURT: No. Just be sure all the members of the
6 jury see it. I think you've got it turned around so some of
7 them on the back row can't see it too well.

8 Q Mr. Kaley, can you explain this portion of the chart which
9 refers to the as-produced Aroclors?

10 A Okay. Monsanto produced a series of products which were
11 marketed as Aroclor mixtures or Aroclor fluids. If we would
12 ignore for a minute the 1016 in the initial column heading, if
13 we look at 1242, 1248, 1254 and 1260, the 12 was an internal
14 code within Monsanto which designated these products as
15 polychlorinated biphenyls or PCBs.

16 The second two digits, the 42, 48, etc., spoke to the
17 percentage of chlorine in the mixture as produced. So that
18 chemists have a way of measuring the percentage of a given
19 element in a mixture. If we looked at 1242, that would tell us
20 that that material on average was 42 percent chlorine by
21 weight; we weighed all the atoms that were in that molecule, 42
22 percent of that weight would be accounted for by chlorine.
23 Same for 1254 would be the 54 percent chlorine by weight.

24 I might speak to 1016 for a moment. 1016 was a material
25 developed by Monsanto during the 1970s to be a more

1 environmentally compatible PCB. It's very closely related to
2 Aroclor 1242; and, in fact, contains about 41 percent chlorine
3 by weight. So that, in fact, under normal circumstances we
4 might have called it 1241. The reason it was called 1016 was
5 because as it was developed as an experimental material, a test
6 material for our customers, we had what we called our MCS
7 numbers which stands for Monsanto Chemical Substance. It's
8 just a sequential number of new compounds that Monsanto tests
9 for a variety of reasons. They have nothing to do with the
10 fact whether it's a PCB or not.

11 Our customers began to call this material by its MCS
12 number, MCS 1016, so that when we commercialized it, rather
13 than changing the numerical designation, we left it as 1016.

14 Q What do the numbers that are in the columns underneath the
15 various Aroclor designations mean?

16 A Okay. If we look at the far left-hand column, it speaks to
17 chlorine molecules. This goes back to the homologs or congener
18 classes I just spoke about. So that the first row of that
19 column, row one means that there's one chlorine on the two
20 rings in the molecule, so that would be a monochlorobiphenyl
21 and so on down the chart. If we get to four, that means that
22 there were four chlorines on those rings.

23 The numbers in the table itself speak to the percentage of
24 each product composing -- or composed of these various congener
25 classes. If we look at 1242, for example, the chart tells us

1 that the material contained one percent monochlorobiphenyl or
2 one chlorine biphenyl. It contained 16 percent two chlorine
3 biphenyl, it contained 49 percent or almost half three chlorine
4 biphenyl, 25 percent four chlorine, eight percent five
5 chlorine, and one percent six chlorine.

6 If we look at the chart, as you can see, as you might
7 expect, as the numbers in the Aroclor series increase, the
8 number of more highly chlorinated materials increases also. So
9 if we look at Aroclor 1260, we note that 38 percent or just a
10 little under half of that material is six chlorines. That then
11 accounts for the fact that it has more chlorine by weight
12 because on average there are more chlorines on each molecule.

13 Q Okay. Am I correct that given this chart that, for
14 example, the contents of 1016 and the contents of 1260 have
15 only an overlap in these two and otherwise contain completely
16 different molecules?

17 A That's correct, Mr. Fruehwald. If you look at the chart,
18 whereas Aroclor 1016 does contain 21 percent,
19 tetrachlorobiphenyl, the first -- the lowest chlorinated
20 material in 1260 is, in fact, a four chlorine biphenyl and
21 there's only one percent of that. So there is very little
22 overlap among the molecules making up those two mixtures.

23 Q Mr. Kaley, have you done experiments and research as to
24 whether the different Aroclor mixtures behave differently in
25 various physical characteristics?

1 A Yes. We've done work like that at Monsanto as have a
2 variety of people in other laboratories throughout the world.

3 Q In what characteristics do the different Aroclor mixtures
4 respond differently?

5 A Okay. If we think, first of all, as just what does this
6 material look like, there are differences in the products on
7 that basis. The Aroclor 1016 and 1242 are clear liquids,
8 almost like a very lightly colored vegetable oil, a Wesson oil
9 type material. As we go up to 1254, the material begins to
10 look like a thick amber, yellow molasses. Aroclor 1260 at room
11 temperature is, in fact, a waxy solid. So we have a range in
12 the appearance of the materials.

13 Another characteristic of interest is the solubility in
14 water of these various Aroclor mixtures. As you know if you
15 put sugar in your tea or sugar in your coffee, you can put in
16 sugar and it will all dissolve, and if you put a little more
17 sugar, that will all dissolve. Pretty soon you get to the
18 point where you can put in enough sugar that no matter how much
19 you stir your coffee and no matter how hot it is, some of that
20 material is not going to go into that solution any more. You
21 have saturated the solution. You can't put any more sugar in
22 that coffee.

23 The same kind of characteristics can be described for PCBs
24 or any chemical. We put the material in water and try to see
25 how much of that material will dissolve in the water. So

1 that's one characteristic we look at.

2 Another characteristic we looked -- or we have looked at is
3 how quickly does the material evaporate, what is its tendency
4 to evaporate. If you leave a bowl of water sitting in your
5 kitchen over a period of a day or two, that water will
6 disappear. Same thing will happen with chemicals. Some of
7 them will disappear more quickly than others.

8 So for instance Aroclor 1242 has what we call a higher
9 vapor pressure or greater tendency to evaporate than 1260.
10 Aroclor 1260 has essentially no tendency to evaporate. It will
11 sit for a long, very long time and you will notice a change in
12 volume.

13 Q What other characteristics have you detected differences
14 among the Aroclors?

15 A We have looked at their behavior in the environment, how
16 they are degraded by micro-organisms. We've looked at the way
17 that they behave in soil, how tightly they adhere to soil,
18 whether they can be washed out of soil by water or other
19 chemicals. So a variety of things have been investigated for
20 these materials.

21 Q Let's go through the various items that you mentioned.
22 First the question of solubility. How do the Aroclor mixtures
23 or the molecules differ in their solubility?

24 A Okay. The solubility, as I said, is the tendency to
25 dissolve in water, so a high solubility means that more

1 material will dissolve in water. The lower chlorinated
2 materials will dissolve to a greater extent in water than the
3 lower chlorinated material.

4 In other words, Aroclor 1242 or 1016 has a higher water
5 solubility than Aroclor 1260. Although we need to mention that
6 in normal terms, the solubilities are very, very low in any
7 case, they certainly will not dissolve in water to the extent
8 that sugar or salt will.

9 Q Has it been determined by experiment what the maximum
10 solubility of any of these compounds is?

11 A Yes. The Aroclor 1242, and since Aroclor 1016 is very
12 close, dissolve in water at about 200 parts per billion. So
13 less than a part per million of these materials will dissolve
14 in water.

15 Q When you talk about the maximum solubility of a substance
16 as you just have, what's the procedure to determine that?

17 A To determine maximum solubility and determine what we
18 consider solubility, we go through a very -- in fact, what you
19 would call a tedious procedure to make sure we get the maximum
20 amount, the most material to dissolve we can.

21 We put the material in water. We may, in fact, heat the
22 water to make the material dissolve more easily. Sugar for
23 instance will dissolve in hot coffee much easier than cold ice
24 tea. And we shake the water and the PCB mixture together for
25 periods of 48 to -- 48 hours to a week to be sure that we have

1 got as much PCBs in the solution as possible to try to maximize
2 the value.

3 Q When you say the maximum solubility of PCBs or Aroclor 1242
4 is in the neighborhood of 200 parts per billion, that's not
5 what you would find in any sample that had not gone through the
6 treatment that you have described?

7 A That's correct. In general, if you just put PCBs and water
8 together, you would measure a much lower number for the
9 solubility.

10 Q Over at the other side of the chart there's a reference to
11 different percentages dissolved in water. Can you explain what
12 that's about?

13 A Okay. As we talked about solubility among the mixtures, we
14 noted that the more -- the lower chlorinated materials
15 dissolved to a greater extent than the higher chlorinated
16 materials. This is really a result of the fact that the lower
17 chlorinated materials considered as congener classes, as the
18 number of chlorines on the molecule dissolve much more readily
19 so that the monochloral and two chlorine materials will
20 dissolve in water at a much higher level relatively speaking
21 than the four or five molecule.

22 If you do the experiment I described and try to measure the
23 solubility and then look at the material that's been dissolved
24 in the water, it turns out that it doesn't look like the
25 original material anymore. The reason is that the more low --

1 the more lower chlorinated materials, for instance, the
2 monochlorobiphenyls go into water very nicely. And, in fact,
3 if you look at the chart where -- let's look at the 1016
4 numbers, the first numbers in each one.

5 1016 as a product manufactured by Monsanto only contained
6 one percent of the one chlorine molecule. After we have done
7 our experiment to try to dissolve it in water, 12 percent of
8 the material that dissolved in water is now monochloral or one
9 chlorine biphenyl. The same thing can be noticed for the
10 dichloral. It goes up.

11 If we look at the four chlorine -- well, that's probably
12 not quite so good. Well, the four chlorine for 1016 doesn't
13 change very much. But you can see that as you go to more
14 chlorines on the ring, the relative amount dissolved in water
15 goes down.

16 Q You have mentioned another characteristic of evaporation.
17 How do the different Aroclor mixtures vary in terms of their
18 evaporation?

19 A Okay. The same characteristics that we've described to
20 solubility also apply to evaporation. The materials with
21 less chlorine on the rings evaporate more rapidly. So that as
22 I mentioned in my general discussion, Aroclor 1242, the mono
23 and dichlorobiphenyls will evaporate fairly readily from a
24 material sitting in air.

25 If we looked at 1260, it would be very hard to even measure

1 any evaporation at all. That material will tend not to
2 evaporate at all.

3 Q Okay. You mentioned also biodegradation. First off,
4 explain what that means and how you test for it.

5 A All right. Biodegradation is a term which is used to
6 describe how the material behaves in an environmental system
7 where there are micro-organisms or what we call bugs available.

8 The bugs are around us everywhere, as we all know. We have
9 bugs in our body. We have bugs in our gardens, micro-
10 organisms, bacteria and small things that have to live. And
11 these things live by eating materials that are available to
12 them. And if there are chemicals available, they will eat
13 chemicals. In fact, everything is chemical so they are always
14 eating chemicals in one form or another.

15 We measure what we call then the biodegradation by putting
16 a chemical of interest, in this case PCBs is what we're talking
17 about, we put the chemical of interest in a system containing
18 micro-organisms and measure how rapidly those bugs eat the
19 PCBs. We do it under controlled circumstances and over a long
20 period of time to get what we consider a valid measure of
21 biodegradation.

22 Q Have you done these type of experiments yourself?

23 A I have participated in these experiments and have done
24 analyses of samples which have been taken from experimental
25 systems. I've not actually fed the PCBs to the bugs, but it

1 was being done in the group I was working in.

2 Q Have you reviewed the literature on biodegradation of PCBs?

3 A Yes, I have.

4 Q Do PCBs biodegrade -- or biodegrade?

5 A Yes, they do. The common wisdom is that PCBs are not
6 degradable. If you put PCBs in the environment, they will be
7 there. In fact, that is in general not true, especially if we
8 look at the lower chlorinated materials, the Aroclor 1016s and
9 1242s, put in an environmental system, put in a soil system
10 containing bugs, put in a sewage sludge system containing bugs,
11 put in a river containing bugs or a sediment containing bugs or
12 micro-organisms, they, in fact, are degraded over time.

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1 Q Mr. Kaley, has Monsanto done research as to the rate of
2 biodegradation of any of the Aroclor products?

3 A Yes. That was a very extensive part of the work our group
4 was doing in the early 1970's.

5 Q I show you what has been marked as Exhibit 5606. Can you
6 identify what that is, please.

7 A This is a report generated from the group that I worked in
8 at Monsanto when I first joined the company, an actual
9 published paper describing the work that Monsanto has done on
10 biodegradation of PCBs.

11 Q Was this paper distributed to anybody else besides Monsanto
12 employees?

13 A Yes, this paper was published in a scientific journal
14 available to anyone who was interested.

15 Q This document doesn't contain a date on its cover. At any
16 rate, do you recall the approximate time this was published?

17 A The work would have been done in the early 1970's. I would
18 guess the publication date would have been--I don't know for
19 sure--I would guess '73, '74, or something like that. '73 or
20 '74. It may have been a little earlier or a little later but
21 in the early to mid 1970s.

22 MR. FRUEHWALD: Your Honor, let me offer at this time
23 Exhibit 5206.

24 MR. KARAGANIS: Your Honor, if this witness wants to
25 speak to his own research or wants to use the learned treatise

1 exception to the hearsay rule, I have no objection. But this
2 is a research article. The normal way it's supposed to come in
3 is either through reliance or quoting the appropriate passages,
4 not the entire document.

5 THE COURT: I understood it was something he did or
6 participated in doing; is that right?

7 THE WITNESS: Yes. This specific paper I didn't
8 contribute to. I have done that type of work that is described
9 in this paper.

10 MR. KARAGANIS: He is not the author or one of the
11 participating researchers. He can quote from it under the
12 learned treatise doctrine. I have no problem with that, Judge.

13 THE COURT: I think that's right.

14 Q Mr. Kaley, can you tell us please what, as a result of this
15 research and the research you have seen, can you give us any
16 kind of quantification of the rate of degradation that you
17 would expect or could be expected from this research of any of
18 the Aroclor products?

19 A There is a table in this publication which summarizes the
20 results Monsanto obtained for a variety of these products. For
21 instance, Aroclor 1016 over a period of 48 hours in a
22 biodegradation system degrades at a rate looks to be about 32
23 percent. So over a period of 48 hours in the system, 48
24 percent of Aroclor 1016 will degrade.

25 Q How does that compare to 1242?

1 A 1242 is slightly lower. It looks to be about 25 percent
2 from the chart presented here.

3 Q Are you aware of any research on any kind of longer term
4 perspective of degradation in terms of the ultimate rates?

5 A Yes, I am. There is work reported in the literature and
6 there was also work done at Monsanto and in fact also in the
7 European labs at Monsanto which have described some of these
8 types of studies.

9 Some of the or one of the numbers I recall for Aroclor 1016
10 was over a period of 100 days or a little over three months,
11 about 90 to 95 percent of the Aroclor 1016 disappeared as a
12 result of biodegradation.

13 Q When you talk about these rates in these experiments, these
14 are optimum degradation conditions, are they not?

15 A Yes, that's right. Before the experiment is actually
16 begun, we do what we call acclimating the micro-organisms. We
17 feed the micro-organisms increasing amounts of the material to
18 get them used to eating this particular material.

19 It's like going to a different kind of restaurant. You
20 don't know whether you like the food or not. You eat a little
21 bit at a time. And then pretty soon you might develop a taste
22 for it.

23 Micro-organisms do the same thing. They don't necessarily
24 jump right in and gobble everything in sight. But they over
25 time can develop a taste for a chemical. And that's what

1 happens. So we use bugs that have developed this taste.

2 Q What would you expect of the rates you have been talking
3 about in terms of a system in the environment or a sewage
4 treatment plant that had not gone through these conditions?

5 A They would be somewhat lower depending. They could go from
6 significantly lower to just slightly lower depending on whether
7 the materials had been supposed to these or similar compounds.
8 But you would expect them to be lower.

9 Q How do the other Aroclors compare in terms of degradation
10 rates you talked about for 1016 and 1242?

11 A As the weight of chlorine goes you up, the bugs don't like
12 it as well. So that 1248 degrades at a lower rate than 1242,
13 1254 even slower, and 1260 degrades even slower.

14 Q You also talked about characteristics in soil. Can you
15 explain what you are looking for and what methodology is used
16 to examine that quality.

17 A One of the things that we are concerned about with the
18 material that's for one reason or another that gets into the
19 environment is what happens to it if it is in the environment,
20 if there is a spill of the material.

21 One of the things that can happen is that the material
22 binds very tightly to soil or other materials that are in the
23 environment. And it turns out that PCBs do this. PCBs, we
24 talked about solubility. And their water solubility is very,
25 very low. They don't like to be in water.

1 What they do like to do is be bound to something like soil
2 or like another organic compound so that they can avoid being
3 dissolved in water. PCBs then adhere to soil. This adherence
4 also increases with increasing Aroclor numbers.

5 So that the Aroclor 1254s and 1260s more tightly bind to
6 soil, hold onto the soil than do Aroclor 1016 and 1242.

7 Q Did Monsanto do experiments to determine the rates of
8 migration through soils and their adherence to soils?

9 A Yes, there were some experiments done to look at what
10 happens. Basically we were investigating what happens if PCBs
11 are spilled on soil and then the rains come and other
12 environmental effects happen. What happens to the PCBs?.

13 So we would take a column of different kinds of soil, put
14 some PCBs on top of the soil, run water through that soil, and
15 determine whether the PCBs would do what we call leach or
16 migrate through that soil column.

17 Q What was found by doing those experiments?

18 A Basically the experiments that have been done and have been
19 published by Monsanto show that only for Aroclor 1016 and only
20 for very sandy soils, soils which do not contain much clay or
21 organic matter, do the PCBs leach through or reach the bottom
22 of that soil column at all.

23 Q What does that mean for an environmental situation? What
24 is a comparable environmental situation that that experiment is
25 designed to recreate?

1 A There are a couple things. One would be a spill, a
2 transformer for instance that contained PCBs should happen to
3 develop a leak, that material material was spilled on the soil.
4 Those results tell us that the PCBs are going to stay where
5 they are spilled. They are not going to move through a soil
6 column.

7 The same approach could be used to describe the expected
8 behavior of PCBs in a landfill. They would be expected to stay
9 on the top of the soil basically where they were put rather
10 than migrate through the soil as it rained or other things
11 happened.

12 Q Does the migration of PCBs through the soil change with the
13 presence of other chemicals?

14 A Yes, it does.

15 Q How is that affected?

16 A Again we are going back to the question of water solubility
17 and the fact that PCBs don't like to be dissolved in water. So
18 if it rains and you are talking about water moving PCBs through
19 the soil, they tend to stay on the soil.

20 There are other materials which would move PCBs that PCBs
21 like to be dissolved in. For instance, a common solvent we
22 would talk about would be something like hexane or even
23 something we talked earlier a little bit about, Wesson oil, or
24 a vegetable oil. PCBs would dissolve very nicely in a
25 vegetable oil.

1 So if you had a column of soil and poured a great deal of
2 vegetable oil on it, then the PCBs would move through that soil
3 because they would dissolve in the vegetable oil and be carried
4 through with that vegetable oil.

5 Q Mr. Kaley, you joined Monsanto in what, 1973?

6 A Yes.

7 Q Had the technology for detecting and measuring PCBs been
8 completely developed?

9 A No. It's not been completely developed to this day. It's
10 a continuing area of scientific research.

11 Q Recognizing that we are all laymen, can you describe for
12 the jury in as simple terms as you can, what you have to do to
13 measure PCBs or to find them at the parts per million level in,
14 for example, water or any kind of sample.

15 A Okay. Bear with me. If PCBs are present in water at a,
16 say a part per million--that's a nice round number; let's talk
17 about a part per million--it is not possible to take that water
18 and throw it into some sort of black box and get a number that
19 comes up on a screen that goes one.

20 There is a very complicated procedure that must be gone
21 through. The first procedure that we have to do is to get the
22 PCBs away from the water. We do that by taking an organic
23 solvent--I mentioned hexane earlier. Hexane is much like
24 gasoline. We could think of it as a gasoline type material.
25 You have heard of the octane number in gasoline. Hexane is

1 much like octane. It's a gasoline type material.

2 We add that to the water and shake it very hard. The PCBs
3 don't want to be in the water. They want to be in the hexane.
4 So they move to the hexane layer. We can then throw away the
5 water because it doesn't contain PCBs anymore.

6 We take the hexane and evaporate it. Hexane is a very
7 volatile material. If you leave a little in a dish sitting on
8 the table, it will evaporate in a matter of minutes.

9 So we evaporate the hexane which concentrates the PCBs to a
10 much higher concentration. If we started with, for instance, a
11 gallon of water, and let's say then we--let's talk about a
12 quarter. It's easier. We start with a quarter of water and
13 say we put in a quart of this hexane.

14 We would end up after our first step with a quart of hexane
15 containing still one part per million PCBs because we have the
16 same volume. If we concentrate that hexane down to a
17 thousandth of a quart, then we have--the PCBs do not evaporate
18 because they have much higher boiling points than the hexane.
19 So they stay there.

20 Since we have a thousand times less volume but the same
21 level of PCBs, we now have a small volume of hexane containing
22 instead of a part per million, a thousand parts per million of
23 PCBs. We have concentrated it by a factor of a thousand.

24 Q What is done with this concentration in 24 of what
25 equipment is used thereafter to make the measure?

1 A After we measure, after we concentrate it, we use an
2 instrument called a gas chromatograph which is basically an
3 instrument for separating chemical compounds.

4 Chromatography is a very widely used technique in
5 analytical chemistry. Basically it separates compounds based
6 on their tendency to adhere to a solid material, a powder, a
7 sandy type material, in a glass column.

8 In fact, each of you have probably done some chromatography
9 without thinking about it. If you have ever written a note on
10 a piece of paper napkin and then that napkin has got wet, you
11 will notice sometimes that the material, the ink spreads out.
12 You might see a red band and blue band and purple band from
13 where the ink has moved along that napkin.

14 That, in fact, is doing chromatography. Gas chromatography
15 is a fancy way of doing the same thing. Each of the bands
16 represents a chemical that is present in the ink. And you can
17 visualize it with ink. With PCBs you can't visualize it. But
18 the instrument visualizes it for you. So you are essentially
19 separating the components of the mixture.

20 Q When did the technology to be able to measure PCBs in that
21 type of a quantity, when did that develop?

22 A The problem with PCBs is that when they are present in the
23 environment, they are present with a lot of other materials.

24 Chromatography really developed--the basic chromatography
25 developed about the early 1950's. But about the middle of

1 1960's, around 1964 to 1966, a new technique for detecting the
2 PCBs, measuring the PCBs, after they came out of the
3 chromatograph was developed, something we call an electron
4 capture detector.

5 We need to know nothing about it other than the fact it is
6 very, very sensitive to PCBs. It will see much lower levels of
7 PCBs than the detector used previously. And also it will pick
8 PCBs and other materials containing chlorine out from chemicals
9 which do not contain PCBs.

10 Q Prior to the middle 1960's, was there technology around
11 that could detect PCBs at those levels?

12 A No, there wasn't. It really took the development of this
13 technique in the 1960's to measure the part per million.

14 MR. KARAGANIS: Are we talking about part per million?

15 MR. FRUEHWALD: Yes.

16 THE WITNESS: We are talking about parts per million,
17 give or take some, yes.

18 Q Since that time, has the technology for detecting and
19 measuring PCBs increased?

20 A Yes. As I said, when we initiated this questioning, it has
21 continued to develop even to the present day. The detector,
22 the electron capture detector, was improved significantly from
23 the mid sixties when it was developed through the mid
24 seventies. By the mid seventies it was probably as good as
25 it's going to get.

1 But there were other techniques developed. There were new
2 ways of doing chromatography developed that allowed us to do
3 much better separations. So there have been a whole series of
4 improvements.

5 Q What was the level of detection given the best technology
6 in 1970, if you can give us--

7 A In 1970, if we are going to talk about water, I would say
8 probably 10 to 100 parts per billion would have been a good
9 technique about that time.

10 Q What is it today?

11 A Today a good analytical chemist in a good laboratory can
12 probably do tens to hundreds of parts per trillion fairly
13 routinely.

14 Q Mr. Kaley, when you were doing work at Monsanto in your
15 initial employment in the group you described, did you have any
16 contact with the Westinghouse Corporation?

17 A Yes, I did.

18 Q What was that contact?

19 A Well, as I described earlier, I was hired as an analytical
20 chemist. And came into Monsanto at the time we were developing
21 new products and really beginning to, not beginning--it had
22 been a long time--but we were concerned about the behavior of
23 our materials in the environment.

24 One of the things we were doing was working with our
25 customers, from my point of view, on an analytical basis to be

1 sure that our customers, Westinghouse included, were able to do
2 low level PCB analyses as well as we thought we could.

3 So we worked with some people from Westinghouse comparing
4 our analytical techniques, comparing the results we got on what
5 we call split samples that would take a quart of water. And we
6 would get a pint, and Westinghouse would get a pint. We both
7 do the analyses and see if our numbers were the same.

8 Q Who did you work with at the Westinghouse Corporation in
9 connection with that work?

10 A My contact there was a name names Mr. Kurz.

11 Q Let me show you what has been previously marked as Exhibit
12 4646 in evidence. It's a letter from Mr. Kurz to Scott Tucker.
13 Who was Mr. Tucker in relation to your work?

14 A Scott Tucker was my group leader at the time I joined
15 Monsanto. He was my immediate supervisor.

16 Q Are you familiar with the work samples that are described
17 in that letter?

18 A Yes.

19 Q Was that the type of analytical improvement you were
20 discussing earlier?

21 A Yes, that's correct. I am sure many of these results were
22 generated by me.

23 Q Were the results of your work of your analytical lab ever
24 communicated to the marketing department or the other
25 management in Monsanto?

1 A I don't have any recollection of that. My results would
2 have been--we talked on the phone to the Westinghouse people.
3 Basically we were lab people working together to compare
4 results. I know I talked to Mr. Kurz.

5 The results were obviously communicated to my supervision,
6 but I don't know where else they may have been communicated.

7 MR. FRUEHWALD: I believe that's all I have, Your
8 Honor.

9 CROSS-EXAMINATION

10 QUESTIONS BY MR. KARAGANIS

11 Q Mr. Kaley, would you be kind enough to explain to the jury
12 the difference between a lab experiment and a field experiment.

13 A Well, the basic difference is a matter of scale. A
14 laboratory experiment is designed to look at a small system to
15 give us an idea of what might happen in a larger system.

16 So we use pints or quarts of material rather than gallons
17 of material. Basically that's the difference. It's a matter
18 of scale.

19 I guess the other difference would be we tend to use purer
20 materials that might be encountered in an environmental system.
21 We are looking for specific chemicals rather than a large
22 mixture of chemicals.

23 Q Would it be fair to say that doing a table top experiment
24 in the lab, that you are able to control the variables that you
25 are applying to the exercise much more carefully than in the

1 field?

2 A Certainly that's true, yes.

3 Q Would it be also be correct that basically you are--the
4 stirrer in the experiment you described, the number on that was
5 5206? The device in which materials were placed for purposes
6 of measuring degradation was a device of 1500 milliliters?

7 A If you are reading it, I will take your word for it. That
8 sounds appropriate. That's a quart and a half. That's
9 probably about right.

10 Q I want to be careful. You take a look at it and tell me.

11 A Yes, that's correct. It's about a quart and a half.

12 Q So the experiment on degradation was done in a jar. And
13 what was done with the jar, the quart jar?

14 A The quart jar contained water which also contained sewage
15 sludge. It was put in a laboratory. It was stirred.
16 Mechanically stirred. We had a little stirring bar in the
17 middle that kept the sludge dissolved in the water so we would
18 have good contact.

19 Periodically, it was also aerated. It had oxygen added or
20 air added to the system because the micro-organisms need air to
21 survive.

22 Q You indicated that in 1016, what were the percentages in
23 the lab experiment?

24 A As I recall, it was in the mid to high 30 percent
25 degradability.

1 Q 30 percent in 48 hours?

2 A That's correct.

3 Q Does that mean there would be another 30 percent in the
4 next 48 hours and another 30 percent.?

5 A That's correct. But we continually fed the system from
6 day-to-day. So that as the material degraded, more material as
7 added day-to-day. We were feeding the material, the bugs the
8 materials, every 48 hours.

9 Q If you were looking at this thing and stopping and kept
10 mixing up and things like that, how many days would you take to
11 get down to zero? I am not having word problems.

12 A In the particular system that we were using in the
13 laboratory, we might never get down to zero. We talked earlier
14 the fact that the lower chlorinated materials tend to degrade
15 more readily than the higher chlorinated materials.

16 So in fact if we are measuring 30 percent degradation, that
17 30 percent degradation is primarily made up of the tri and di,
18 the two and three and one chlorinated materials. So that the
19 fours and fives, what little fives were in there would continue
20 to accumulate.

21 Q So the 1016 that was left would start looking more with a
22 higher percentage of the heavier chlorinated compounds; is that
23 correct?

24 A That's correct.

25 Q As a matter of fact, so-called degraded environmental

1 samples of 1016 often look like other kinds of PCBs to the lab
2 analyzer, do they not?

3 A They resemble. I don't know that they really look like
4 them, but there are some similarities.

5 Q What typical compounds do they look like?

6 A Well, over a period of time, they will begin to have more
7 and more of the characteristics of an Aroclor 1248 or an
8 Aroclor 1254.

9 Q And that's true of 1242, is it not?

10 A It's more true of 1242 than 1016. 1016 was designed not to
11 contain very much of these five and six chlorinated materials.
12 So it would not--it would not have the tendency to resemble the
13 others as much as 1242.

14 Q But it would have that tendency but just not as much?

15 A To a certain extent, that's correct.

16 Q Let's stay with 1242. What was the rate on that?

17 A As I recall, it was mid twenties, 25 percent.

18 Q So if my arithmetic is right, that's 25 percent in 48
19 hours?

20 A That's correct.

21 Q And then another 25 percent in the next 48 hours?

22 A 25 percent of what was added additionally.

23 Q In a couple of weeks, I am basically down to nothing; is
24 that right?

25 A In the system we were using in the laboratory, we have

1 continued to add Aroclor 1242 to the system. So that the 25
2 percent from the first day, then we added more PCBs; and 25
3 percent of that total was then degraded. We added more PCBs
4 than 25. So we didn't actually do the experiment trying to get
5 down to zero.

6 Q If you stopped adding PCBs to the system and kept mixing
7 around and adding air and doing whatever you were doing, 25
8 percent the first two days, 25 percent the next two days, by a
9 couple of weeks, we would be down to pretty close to nothing?

10 A That's not true. As I just described, the materials that
11 we are measuring the biodegradation of tend to be the lower
12 chlorinated materials.

13 Q What would we have left?

14 A You would have the higher chlorinated materials will begin
15 to accumulate. Those will not degrade at a rate such that in
16 two days, we would notice that degradation or even possibly
17 weeks. So that we would never get to zero in that system.

18 Q The higher chlorinated compounds that are present, the ones
19 that would remain after degradation, are present in 1016 and
20 1242?

21 A They are more present in 1242. It depends on which
22 particular congeners we are talking about. But there are
23 certainly traces of those materials even in 1016.

24 Q And basically again, if you add enough 1016 and the light
25 stuff degrades, you have still got a lot of heavier chlorinated

1 compounds?

2 A That's true. The material, the heavily chlorinated
3 material, will not degrade nearly as rapidly and will continue
4 to accumulate.

5 Q The input that you have got to add is how much you are
6 putting into your experiment; is that right, how much 1016 or
7 1242 you are putting in?

8 THE WITNESS: I am not sure I understand the point of
9 your question.

10 Q If I put a little 1016 into the experiment, I will have a
11 little of the heavier chlorinated compounds left.

12 A That's correct.

13 Q If I put a lot of 1016 into the experiment, I will have a
14 lot of the heavier chlorinated compounds left?

15 A On a relative basis, that's certainly correct.

16 Q That's my level of arithmetic.

17 Have you tested your hypothesis at the Bloomington lagoon?

18 A I don't have a hypothesis, but I have not tested the
19 Bloomington lagoon, no.

20 Q Let me ask is there anything about the sewage lagoon at
21 Bloomington which would, or any sewage lagoon, which would tend
22 to retard or degrade your ability to biodegrade, to limit your
23 ability?

24 A Well, as I mentioned in describing the experimental system,
25 it was made to optimize biodegradation. So it was stirred.

1 Oxygen was added. So if some of these things did not happen,
2 certainly the biodegradation rates would be lower.

3 Q It would be significantly lower, would it not?

4 A Depending on the extent of the differences, correct.

5 Q As a matter of fact, in an oxygen-poor system where pH
6 isn't being controlled, there are things that could very well
7 stop biodegradation almost altogether; isn't that right?

8 A If the bugs died, the biodegradation would stop.

9 Q In a lagoon that is oxygen poor--are you familiar with
10 sewage lagoons that are oxygen rich?

11 A Most of the ones that I am familiar with have some means of
12 oxygenation or aeration, yes.

13 Q Mr. Kaley I am not talking about the aeration lagoons of a
14 sewage treatment plant. I am talking about the sewage lagoon
15 where the sewage that is in the final clarifying--excuse me.

16 MR. FRUEHWALD: I object to this line of questioning.
17 Mr. Kaley was not giving opinions on the Bloomington situation.
18 He was giving general opinions on expectations about the
19 product and the chemicals rather than any application to
20 Bloomington.

21 MR. KARAGANIS: He has raised aeration, and I am
22 entitled to ask about whether or not the lagoon is aerated.

23 THE COURT: Go ahead.

24 MR. KARAGANIS: I will be brief.

25 Q Mr. Kaley, I show you what has been marked as Plaintiffs'

1 Exhibit 4520.

2 When you are talking about an aeration in a sewage
3 treatment plant, what chamber are you talking about?

4 A I am no expert in sewage treatment plants, but I guess I am
5 talking about an aeration chamber. I am not an engineer, and I
6 am not familiar with the operation of the plant.

7 Q If there is not an aeration chamber in a sewage lagoon, is
8 it possible that degradation might be much slower than you told
9 in your testimony?

10 A Well, it would certainly--if there were no means for oxygen
11 exchange--obviously, there is some oxygen exchange on an open
12 system--but the rate will depend on how much oxygen is getting
13 into the system, no question about that.

14 Q And if there are low oxygen--are you familiar with the term
15 anaerobic condition?

16 A Yes, I am.

17 Q If there is no oxygen or little oxygen, could the process
18 take tens of years?

19 A I think it could. There is work coming out of General
20 Electric Laboratories which say--which they have found their
21 anaerobic processes, oxygen poor or oxygen absent processes,
22 which will degrade PCBs so that there are those processes which
23 can then take over. But the aerobic will certainly decline.
24 Could they last ten years? It's conceivable.

25 Q Could it be hundreds of years?

1 A I don't know the answer to that. PCBs have only been
2 distributed 60 years. Whether they can last hundreds, I don't
3 think anybody knows the answer to that.

4 Q It's not your testimony here today that the PCBs in
5 Bloomington, if we simply wait a few weeks, will go away?

6 A I would be very surprised if that happened.

7 Q Let's take movement of PCBs. When you talk about how PCBs
8 move, again, some of your testimony was based on laboratory
9 experiments, was it not?

10 A Yes, some of it was.

11 Q That's taking a soil column in a large glass tube and
12 pouring PCBs on the top and see if any come out the bottom?

13 A That was a rough description of one of the experiments we
14 did, yes.

15 Q Isn't a landfill, doesn't that give us essentially a field
16 experiment? That gives us a soil column, does it not?

17 A Yes, it.

18 Q So if we were to pour PCBs on top of the soil column, if
19 they came down out of the bottom, what could we conclude from
20 that?

21 A Well, we conclude there was some process going on which was
22 causing them to come out the bottom.

23 Q And it's possible, is it not, for field conditions to exist
24 if you pour PCBs in the top, PCBs will come out the bottom?

25 A It's certainly conceivable.

1 Q As a matter of fact, one of the things that when one looks
2 at the ability of soil to adsorb--isn't that the term that's
3 used?

4 A Yes, it it.

5 Q To adsorb a chemical, an organic chemical, there is a
6 limited capacity of the soil column to adsorb a chemical?

7 A That's true.

8 Q And if you pour enough of the chemical on the top, you can
9 exceed the capacity of that soil column to hold all that
10 chemical; is that right?

11 A Yes, that's true.

12 Q So that if you poured enough at the top and you exceeded
13 the capacity of the column, you would get stuff at the bottom;
14 is that correct?

15 A That's correct.

16 Q How did Monsanto test the chemical composition of 1242 in
17 the fifties? In other words, how did they know they had 1242
18 when they made it?

19 A My understanding is it's based on the reaction conditions
20 in the plants they were making it. They basically could
21 measure the weight percent of chlorine in the mixture and knew
22 the conditions to run the plant to get to that weight percent.

23 Q In the fifties, what is the--what was the detection level?
24 If Monsanto wanted to go out in the fifties and detect PCBs in
25 the environment, at what level could that detect it?

1 A I would say tens of percent. I am just guessing. I don't
2 know what technique they would have used in the 1950's.

3 Q 20 percent, 30 percent?

4 A Your guess is as good as mine frankly. I don't know what
5 technique that would have been used at that time. So I don't
6 know what the detection level would have been. But it would
7 have been very high.

8 Q Just so we have our nomenclature right--I have done this
9 before--you have mentioned--and I think I took this down right;
10 I may be in error--290 separate congeners?

11 A Yes.

12 Q 209 congeners or 209 isomers?

13 A 209 congeners.

14 Q What are isomers then?

15 A If we go to our congener classes, so we have 209 congeners,
16 209 individual separate chemicals. We can group those into ten
17 congener classes or homologs depending on how many chlorines
18 they have on the ring.

19 Within each of those congener classes, there are a variety
20 of ways to put that number of chlorines on the biphenyl
21 molecule. If we look at--let's do the easiest first.

22 There is only one way to put ten chlorines on a biphenyl
23 molecule. There are only ten places on the two rings that
24 contain--that may contain chlorine. So there is only one way
25 to put ten on. So there is one isomer of deca, meaning ten,

1 decachlorobiphenyl. There is only one arrangement of those ten
2 chlorines.

3 If we look at pentachlorobiphenyls which means there are
4 five chlorines somewhere on those two rings, there are 46
5 different ways to put five chlorines on those two rings. So
6 there are 46 isomers of pentachlorobiphenyls.

7 There are 46 isomers within that five-chlorine class. We
8 could think of all five on one ring and no chlorines on the
9 other ring. That would be one of the isomers, one of the 46
10 ways to put five chlorines on the ring.

11 So you can, strictly speaking, only talk about isomers of
12 materials in the PCBs case which have the same number of
13 chlorines on the molecule.

14 Q So you only use the isomer within the congener class?

15 A That's the correct usage, yes.

16 Q Now, you mentioned the movement of PCBs through a system.
17 Apart from the water phase--and you acknowledge, do you not,
18 that some PCBs can move in water, a soluble fraction of the
19 water?

20 A Yes, low levels.

21 Q Apart from the soluble water phase, PCBs can also move as a
22 liquid, what they call a nonmiscible liquid; is that right?

23 A If the capacity--we talked earlier about soil capacity. If
24 in fact the soil capacity had been exceeded, then I guess the
25 PCBs could move excluding dissolving in water and moving with

1 the water.

2 Q If you would take a cup of water and pour PCBs on top of
3 water, the PCBs that don't go in the water aren't solid. They
4 are in a liquid nonaqueous phase, are they not?

5 A That's correct.

6 Q PCBs could also move attached to one of these particles
7 that you talk about; is that right?

8 A That's correct.

9 Q If you have a glass of water in your tap at home and you
10 turn it on and the water has a lot of cloudy particles in it,
11 is that particulate matter typically?

12 A Pardon?

13 Q Is that particulate matter?

14 A Yes, it is particulate matter.

15 Q So particulate matter can move through water systems in
16 little fine particles, can it not?

17 A Presumably most water systems are filtered. But there
18 would be some limits of that filtering, I suppose.

19 Q All well water systems are filtered?

20 A I don't know.

21 MR. KARAGANIS: No further questions. Thank you.

22 MR. FRUEHWALD: I have nothing further.

23 THE COURT: That's all. Thank you.

24 THE COURT: Do you have a 20 minute witness.

25 MR. FRUEHWALD: No, sir. This was all I could bring