NATIONAL Life stories

IN PARTNERSHIP WITH BRITISH LIBRARY

NATIONAL LIFE STORIES

AN ORAL HISTORY OF BRITISH SCIENCE

James Lovelock

Interviewed by Paul Merchant

C1379/15

This interview and transcript is accessible via http://sounds.bl.uk.

Oral History
The British Library
96 Euston Road
London
NW1 2DB
United Kingdom

+44 (0)20 7412 7404
oralhistory@bl.uk

The British Library	**National Life Stories**
Interview Summary Sheet	**Title Page**

Ref no:	C1379/15		
Collection title:	An Oral History of British Science		
Interviewee's surname:	Lovelock	Title:	Dr
Interviewee's forename:	James	Sex:	M
Occupation:	Independent scientist	Date and place of birth:	26/07/1919; Letchworth Garden City, Hertfordshire
Mother's occupation:	Art dealer	Father's occupation:	Art dealer

Dates of recording, Compact flash cards used, tracks (from – to): 7/4/10 (track 1-5); 8/4/10 (track 6-13)

Location of interview:	Interviewee's home, Coombe Mill, Launceston, Cornwall		
Name of interviewer:	Dr Paul Merchant		
Type of recorder:	Marantz PMD661		
Recording format :	WAV 24 bit 48kHz		
Total no. of tracks:	13	Mono or stereo:	Stereo
Total Duration:	09:10:50		

Additional material:

Interviewer's comments:

[Track 1]

Right. I was born at Letchworth Garden City in Hertfordshire on July the 26th 1919, in a house on a road called Icknield Way, the old, ancient trackway that goes right the way across Britain from the south-west to, Norfolk I think. And, the house was called Norton Croft, and it was opposite what was called Letchworth Common. It was kind of, halfway between a common and park.

Could you remember that house in enough detail to imagine being at the front door, going into the house, and give me a kind of tour of the house, describing its rooms?

I can, but it won't be very complete. You see, I left that house when I was just turned five years old. So, it's, it's really going back. But I do remember a lot of things. The door was within a porch affair that was on the side of the house at the front, you came into a garden with hedging along it from Icknield Way and then up to the porch and entered the house there. And, I cannot remember whether that house went straight into what was the sitting room of the house or into a corridor that, with the door off. I just can't remember that.

Mm.

But I can remember the sitting room quite well, and a number of incidents that occurred in it. And, that led on through, I think to what would have, in most houses I suppose have been a dining room. And I can't remember that it was always used as a dining room, I don't remember eating in it very much. But it was quite a pleasant room, and it faced out onto the side of the house. And then, beyond that there was a big kitchen with a, a black range that my grandmother was always swearing about because it had to be cleaned and blackleaded to make it shine and look, [laughs] proper. It was, she treated it as many middle-class women treat an Aga stove nowadays, as a kind of curse-cum-sort of advantage. [laughs]

Mm. Yes. And, the rest?

That was the downstairs. And that led, the kitchen then led into, I rather think there was a scullery but I'm not absolutely sure on this point, and a porch onto a fairly sizable garden at the back that was mostly sown with vegetables of various sorts. One wouldn't really think about it as a child.

Mm.

But there were quite a few flowers as, you know, planted flowers as well. And there was also a shed, where my Uncle Frank kept his bicycle, and, there was a bench in there with some tools that they, whatever they did. Again, it's, you know, a long-distance memory, and I can picture it more than know what was going on in it, if you know what I mean.

Yes.

Yes.

[03:21]
Do you remember what at that age you saw as being modern in the house, what sorts of things did you think were particularly modern as objects?

I don't think that the term, word modern would ever have entered my mind as a child then. You, you accepted the world that you came into as new and complete.

Mm.

The first time I encountered anything that I would regard as modern was when my grandmother, as she often did, took us over to my, see my aunt Florrie, who had a house in Hitchin, which was about two or three miles from it. It was a bus journey, and we went from the middle of Letchworth to Hitchin, to my Aunt Florrie's house. And Florrie had just had two remarkable things installed. Her husband owned a tailor's shop in, in Hitchen, on the, in the market square. They must have been fairly prosperous. And, they had telephone and electric light installed, and that, that was really quite remarkable.

[04:26]
Do you remember what in particular you, you felt about seeing the object of the phone? What interested you about it?

Not so much the phone; it was the light that interested me, far more, and the ability to just go up and turn the switch and on it came. That kind of thing. What moves a child of four or five is very different I think from what moves one when you're a lot older.

Mm.

But it was, there was a definite sense of wonder there, no question about it, this was remarkable.

[04:57]
In the autobiography I sensed that, you were looking back on your birth and the fact that you were in a way sort of handed over to your grandparents to be looked after, and your analysis of that seemed to be that of an adult looking back. And I wondered whether you can...

How else could it have been? I wrote it when I was... [laughs]

Yes of course. But I wonder whether you can take yourself back to your, your child self and remember how you felt about that, about being, spending most of your time with your grandparents and little time with your parents.

It was just the same as the, your question, what did I think was modern? You, as a child I think, children, at least I did, accepted the world as I saw it around me, and on the whole I was very content with it. And I go back to that very first vivid memory I ever had of lying in a pram outside, and I couldn't have been more than two years old, possibly less, and, suddenly becoming aware of the world.

Mm.

The sun was shining, it was a, it, it must have been a nice day. And, although I couldn't have formulated the words, there was a kind of, into my mind came the thought, 'So this is it. This is the world.'

Mm. Mm.

It didn't last long, but there was just, it's a most vivid memory, and one that, it kind of set the seal of a, [laughs] a fairly optimistic, happy person in a world that seemed to be all, all all right. So from then onwards the world of my grandmother's house and, and everything, was the world. My mother was a rare, occasional visitor, who turned up once in a while, and really I didn't remember at all.

Mhm. OK.

Not in a... I... When I say I didn't... I remember the occasions of her coming, but I didn't remember her as a person, in the way that I remembered my grandmother. I had bonded firmly with my grandmother, and, when she died I was quite distraught, even though I was about twenty, because it was the los of my mother as far as I was concerned.

Mm, emotionally, yes, yes.

And... Yes.

[07:22]
What then do you remember as a, I don't know, as a kind of visual event of your mother visiting? Do you remember, you know, what she was wearing?

Almost nothing. I don't, don't... This is it. I didn't really see anyone apart from my grandmother, my grandfather, my Uncle Frank, that was the youngest child of my grandmother's family, who was at that time living at home and travelling to work in London with my grandfather every day on the train that ran from Letchworth to King's Cross station.

Mm.

And, commuting, early, commuting, long ago. I remember them quite clearly. I remember locals like the woman next door, Mrs Stallybrass, who tried to teach me for a while, she was a school, school mistress originally, but now retired. And, I remember my Aunt Florrie that we went to in Hitchin. But, I can't... no, no clear picture comes into my mind of anybody else.

Mm.

Not even my father, who I did... He was a vague figure that did appear, and I knew was there, but I didn't sort of remember any details about him, or the clothes he wore or what.

Mm. So your father visited as well?

That's right. And it would be at things like Christmastime and holidays, things like that.

[08:53]
Mm. I see, thank you. In that case, could we... I know that when you were five you moved back to Brixton, is that right, with your grandparents, when your grandfather retired?

That's right. I think the grandparents stayed on in Letchworth a little longer. They, they got rid of me up to London, to live with my mother, so that they could arrange the... I don't know whether the house was let, whether they rented it, or whether they owned it, I've no idea, but, while they were disposing of it, and the furniture within it and things like that, they didn't want a young child around. And so, I went back to my mother's. They took me of course, but, from then onwards I was in Brixton.

Yes. You say your mother's, your...

My mother's house. Well, my mother and father lived in a shop on Brixton Hill.

Yes. Mm. So, you moved back in with your mother and father, yes?

That's right, yes.

[09:50]
I see. Now in... I was fascinated in the autobiography to note that, when you were describing Brixton, the streets of Brixton, and I'm going to ask you to do that a little bit more in a minute if that's OK...

Sure.

You seemed to have quite a, a sensitivity to the air, to the, to the sort of, the atmosphere, the pollution.

Oh yes.

And, was that a kind of sensitivity that you had then as a child, at five, a kind of, an awareness of...?

Well you'd have to be blind not to be aware. And the, the smogs in the winter were so thick. When, when somebody says they couldn't see their feet, they weren't exaggerating, you really couldn't.

Mm.

And it was quite terrifying on railway station platforms, not to be able to see the edge of the platform. And the train came in as a great glowing thing through the mist, and it was only when the carriage doors were just, up, up before, that you, you, that you could see them clearly enough to enter them.

Mm.

I've never heard of anybody falling on the line during that. I think, it was, it was, it seemed so dangerous, you almost waited until the train came in before moving forward.

[11:10]
Mm. Mm. In that case, could I ask you to describe first of all the accommodation above the shop, and the shop itself?

I can't describe the accommodation above the shop in any great detail, because we never lived there to any extent.

Mm.

We occupied the ground floor.

Oh, OK, yes.

The upper part was either let to other families or else, my grandmother and grandfather occupied it for a while.

OK. Could you describe the ground floor living... yes?

Sure. It was a typical shop, on Brixton Hill. It's still there, we went to see it. I've forgotten what it... I think it's some sort of, cash and carry of some kind now. But anyway, it was quite big, a great big barn of a, a hall which you went into. And, there were, there were shop windows with pictures hanging in them of, mainly from local artists. And, a big long counter along the front. And a carpet on the floor, it was kind of, hessian, it wasn't... it was hessian carpet for, obviously chosen for hard wear, and, it was quite practical. And, opposite the long counter there were, anything could be stored, objets d'art and pictures, big ones, and things like that. And, plenty of space in the middle. And the customers would come in and they would be engaged either by a shop assistant, a Mr Weatherby, or my mother. And, there was a telephone at the far end of the shop, that was one of the things that I noted having sort of been impressed with, Aunt Florrie's telephone. And it was an essential part of their

business. And then below the, the floor, there was a huge workshop with an enormous bench in it, and, on it picture framing and things like that were done. My, my father did quite a big of amateur painting, restoring, the kind of Photoshop job really, people would come in with pictures of various kinds that had been scarred or damaged in some ways, and he would make a good repair so that it looked as if, as if it was the original. He was fairly skilled at doing that sort of thing. That was their business, and they did fairly well, up until the first great depression in 1930, thereabouts.

And, do you remember how the, the sort of living areas were decorated?

Not how they were decorated. I don't think children bother much... I don't even today know; [laughs] it's my wife who notices how a place is decorated. But I do remember an awful lot about it. Behind the shop there was another, huge, room, and... Oh, one thing I do remember about those times is, it was lit, we were lit by gas. We were at Letchworth also, I think lit by gas, but it might have been oil lamps. And it was, the lighting by gas was relatively limited to the downstairs rooms, nearly every... I mean, many places. So that, candles were commonly in use in those days, I mean they were, you would go up, up to bed with a candle, and it was perfectly normal. And probably the source of many fires, but, but that's how it was. And the same was true of the shop. Electric light was a comparative rarity, that didn't come along until, oh, somewhere near the Thirties.

[15:12]
And your... Having eventually sold the Letchworth house and most of the furniture, they moved to the shop as well?

That's right, for a while.

And so at that time you had your grandparents and your...

Parents, that's right.

...your parents.

Yes. So, it wasn't such a shock for me. My parents were incredibly busy. They worked far too hard. You see, the shop didn't produce enough income really to support the whole enterprise. It was a rented property with a very high rent, shops always are, and, a repairing lease, which was quite onerous, things like that. And, my father continued working in a job collecting coins from gas meters around Brixton. And it, it says something about those days. He was a bespectacled, slight-looking man, although he could have defended himself quite well, because his, he won one or two amateur boxing things when he was young. But, he was carrying a great big leather bag full of coins, but he was never mugged.

What did he tell you about his, his work during the war or his service in, in the First War?

He didn't have any service in the war for the simple reason he was too old.

Mm.

You see I was a product of my father's second marriage. He must have been, let me see, approaching his late forties or early fifties when, when he married my mother. And at that... And that was just before the war started. And he would have been way beyond any call-up age at that, at that time. And, so he continued his job with the gas company. In fact he had worked for the gas company since his teens. He had run away to London from the country and taken a job at the Vauxhall Gas Works, just, I think it was just opposite where MI6 is nowadays.

Ah, OK.

That strange, [laughs] peculiar building on the corner of Vauxhall Bridge. And, he worked there for a long time. I should add, I think it's in my autobiography, of course my father was illiterate and innumerate when he went to work in his late teens. He had grown up in the country under appalling conditions, and, that was the way of things. And, he, he was sent to the Battersea Polytechnic at the expense of the boss of the gas works, one chemist, Dr Livsey. One, one tends to forget, Victorian novels put

it in the wrong context, that the gas works in those times as a high-tech industry, the Silicon Valley so to speak of those times. So my father was very lucky to get a job, albeit a labouring one at first, with them.

[18:15]
Mm. Thank you. You, you do mention some time spent with your parents, for example, daily baths and library visits with your mother.

That's right, yes.

And, you also...

Walks with my father.

Walks with your father. I wonder whether you remember in any detail a relatively, might be seen as a sort of mundane detail, but do you remember the daily bath in any detail with your mother, what sorts of things said each other, ways of interacting, that sort of thing?

I can't remember the conversations all that much. I can remember the circumstances very well. There was in the room behind the shop a very large gas fire. I think one of the perks my father got working for the gas company was probably equipment of things like, we had the latest form of gaslights, which had a cord that came down from above and you just pulled the cord and the light went on, gaslight went on. And it was a large thing with about five or six gas mantles in it, and you know the gas mantles, they were the glowing thorium things, that gave quite a good, strong light. So, that was a bit advanced. So was the gas fire, it was a series of ceramic tubes that were heated by a gas flame from below. And it was in front of that that a large galvanised iron bath was placed. And, it, the sort of kitchen arrangements there were exceedingly primitive. Just behind that room was a kind of, shed affair, it was brick built admittedly, which just had inside it not a gas stove or anything like that, but a gas ring on, on a pedestal, and, everything from the bath was heated by sitting it on there and leaving it for a while, and, tea and simple meals cooked that way. And there was a sink just behind that, washing up was done. And beyond that, the lavatory and

wash hand basin. And that was, that was about all they had. There was a shed in the garden that later my father put a gas stove in, and, some of the bathing, certainly in the summertime, not in the winter though, took place out in this shed in a big hip bath.

[20:41]
Mm. And, I wonder whether you can remember any details of, I don't know, how your mother called you to go for a bath, or, how she was dressed, her sort of expectations of you in terms of conduct, that sort of thing. I'm just trying to get a, a measure of the particular relationship you had with your mother as opposed to any other person of that age.

Pretty negative really. You see I hadn't bonded with her. And, I probably regarded her no more, no differently than, a child might regard a nursemaid who was deputed to look after him. And, my mother was a very strange mixture. She was an early feminist, I think she belonged to the suffragists, and, wouldn't go as far as actually becoming a terrorist [laughs] suffragette but she was very much a supporter. She was passionately interested in music and the arts, and, she had a boyfriend. It wasn't, there was no... I'm sure there was no sexual relationship, but, he was an old bachelor that liked, attached himself to the family, and he was also mad keen on music. My father wasn't. And my father was quite happy that Nell was taken to the Queen's Hall and operas and things by old Charlie Wright, who was quite wealthy, this old bachelor. So, it was, that was, I say... and that got... So, I didn't see an awful lot of her really. And, she was either intensely busy working in the shop, or doing the accounts of it and things like that, or else going off on her entertainments of various kinds. The weekends were the best time, because that was when my father was free to take me for walks. My mother and I would walk down to the Brixton Library.

[22:48]
OK, thank you. Now I know that on your visits to the Brixton Library you started by getting books out, H G Wells, Jules Verne.

That's right.

I wonder...

Olaf Stapledon I think.

Mm. Do you remember any particular titles that you borrowed at that time, I think you started then...?

Oh *The Time Machine*, definitely was, was one. And, I think the, was it *The Island of Dr Moreau* was another. [pause] Oh dear. Oh yes, and I borrowed Jules Verne before that I think too. But was less impressed on the whole with those. Wells really turned me on, I thought it was...

Could you expand on 'turned me on', in, in other words, do you remember particular...

A sense of reality, that what he was talking about, his whole description of the time machine and the environment and what happened, all seemed so real. It, it, it almost seemed like a, a post hoc description, not a, not a, an imaginative invention. And, oh that really moved me very much.

And, the other fiction reading. Or, perhaps more on H G Wells. Do you remember any particular images or, you know, visual images or ideas that struck you?

It, it would be quite wrong to give the impression that I was a highly intelligent, advanced child who only read these good books. I read the comics, and the... I don't... I can't remember the name of the heroes there were around then. But the sort of, Dan Dare type of, of books. And, I remember even arguing with my mother, who, who deplored this enormously. 'How can you read that trash?' kind of thing. And I read out a passage from it that to me was quite moving and quite well written. [laughs] But, no, it, it's a very... I think the mind of a child pre-puberty is very much like a sponge. It's, it's almost as if it had evolved to absorb an immense amount of knowledge that was going to be useful for survival later on. And it made no judgements about it, it just took it in, as it was. And, I think the only judgement is the one I made about Wells, was, how real is it? If it, it it's too fanciful, you tend to reject

it, at least I did; but if it, if it seemed to have a, some reality, my mind must have decided that was stuff to keep.

The reality, was that in terms of technical detail, or...?

Situational detail, as much as technical detail.

Mm.

Because I was in no position at that age to decide on technical criteria; it would have to be, does this seem to make sense and be believable?

[26:04]
And is there a link between, or to what extent is there a link between your interest in science fiction in terms of your reading and your interest, it seemed to me, in examples of machinery, big pieces of machinery, trains, the steamer on the Thames...

That's right.

What was the nature of your interest in these pieces of machinery, these...?

I wasn't so much interested in the machinery as such, but it was all part of the application of science and technology. And, it, it was, it became fashionable, I suppose, mainly post World War II, to decry steam technology as old-fashioned and out of date, but you have to remember that in the Twenties it was in its heyday. And, things like the Flying Scotsman steam engine that, that ran from King's Cross to Edinburgh, in times [laughs] that would still be reasonable by today's standards, it was travelling at over 100 miles an hour, we used to see it go through Hitchin station. In fact that was one of the pilgrimages that I made when I stayed in Hitchin, was always to the station for the time when the Flying Scotsman came through. So, it was the kind of high-tech of those days, the space equivalent of today, or, well not today, but of twenty or thirty years ago.

Could you describe your memory of seeing the Scotsman going past at Hitchin?

[hesitates] Yes. You... What we did was to get a platform ticket. You were allowed to go on the platform, if you paid a penny into a machine that stood by the thing and the, the ticket collector at the door let you through onto the platform. And then we went up near the, to the south end of Hitchin station platform, which is just the same now as it was then, and, looked down towards the line towards King's Cross where it would be coming from, and then you would hear the noise coming. And then it would rush through and it was such excitement.

[28:20]
Mm. Mm. Thank you. Other books borrowed from the library, and in your, in your autobiography you talk about then moving on to science textbooks essentially.

Yes.

And one of the ones that you mention was Wade's Organic Chemistry.

Yes.

Are you able to remember things in particular in Wade's Organic Chemistry that interested you at that age, whether it is particular images of compounds or ideas or formula or, I don't know. What in particular interested you about Wade's Organic Chemistry, if you can remember?

Again, like most of the instruction I was putting into my mind in those days, it was a mishmash, and I wasn't all that selective.

Mm.

Being a typical, wretched young boy, and disliking school and things like that, except my dame school, so, that would be, I'm talking, this would be post-nine years old I would be thinking this way, before nine years old, I had started reading books like Wade's *Organic Chemistry*. It was a faithful companion, I would get it all the time. In fact, I still carry on the same thing today. I've got the *Merck Index*, which is the

incredible list of all the chemicals that the company Merck used to sell in America way back in the last, I think in, goes back to the nineteenth century even.

Gosh.

And it's one of the best descriptive textbooks, and is what I call loo reading. I can be happy just going through it and reminding myself of things. Almost devotional [laughs] reading if you like.

Mm. Mm.

And that was how I, I took Wade's *Organic Chemistry*, a very similar way to, to which a religious child might take the Bible, something to absorb and, gain things from. But a little later on of course, I loved to read about compounds that were unbelievably smelly, vile odours, and, longed to have the equipment to be able to make them and make a really super stink bomb, [laughs] to take along to school. That kind of thing. And like all kids I was interested in fireworks and bangs and crashes. And there was no health and safety whatever in those days, and if you blew your hand off in the course of it, well that was very unfortunate and we should have been more careful and, and all the rest. But there was no, no inquest or...

[30:52]
What was your mother's view of you reading that kind of book, Wade's Organic Chemistry?

Nnn... neither negative nor positive.

Mm.

She certainly, there was no objection whatever.

Mm.

And, I think, she, she was passionately fond of the idea of education. I think, it's in my book. She had had a very miserable experience of having passed a scholarship which would entitle her to go to a grammar school but not being allowed to go, because the family needed her capacity to work to add, to supplement the family income when they were quite poor. And when it was, one of the awful things about the working class, there are many good things but an awful thing, was that tribal solidarity. You don't sort of let down your, your tribe by going out... That's why they hate grammar schools so much I think, it's because, it, it's a route out.

Mm.

And I think the, the wise, more liberal and right-wing politicians of Victorian times saw that it was a good idea in Britain to encourage bright children in the working class to have upward mobility, so that you wouldn't be leaving in the working class rebellious potential trouble-raisers. And my mother was a classic example of it, she was very very bitter about that inability to take what she saw as her right to a proper education.

Mm.

And she was a very intelligent woman, and it was a cruel thing to have done to her. So anything I did that was improving knowledge was OK with her. She had nothing against that. She had quite a bit against comics, because that was a, an unnecessary diversion, [laughs] but Wade's *Organic Chemistry*, no, no, that was perfectly OK.

[32:52]
Thank you. Do you remember what you enjoyed about, is it Jeans' Astronomy and Cosmology?

Ah yes, I'm glad you've raised that, because, it would be quite wrong to give the impression that I was limited to chemical information. I was totally broad-ranging at that time in science, and I think the whole subject still was to a large extent. We always seem to forget that the early scientists in, in Britain certainly and in much of Europe, were talented amateurs. For the most part they were gentry, with private

means to build their own laboratories. The idea of university scientists or government was just unknown, it just wasn't on, wasn't part of the scene. And, so, you took science in this wide-ranging amateur way, you just wanted to know more about it and become expert at various things, and as clever as you could be at it.

Mm.

And physics was just as important to me as chemistry. But, I had this profound drawback which has hampered me all my life, of being dyslexic. And therefore, having problem with equations, I can never tell which side I'm on, and waste an awful lot of time checking.

Mm. I see. I wonder what... I know that it's quite a long time ago, but would you remember for example inspiring pages of that book, or of any book, scientific text? In other words, particular photographs, or a particular graph?

I don't have an eidetic kind of memory.

No. No.

But, the kind of thing, I can remember sort of opening Wade's *Organic Chemistry* texts, and on, on the right-hand page, I can't think why I can remember it was the right-hand page, there would be a picture of apparatus assembly of, a distillation column or something like this, and, underneath in the text was that, distilling over, just over forty something degrees Celsius, quite low temperature, came this wonderful refractile liquid that glistened like diamonds in the light. And that was methyl, the preparation of methyl iodide. And, it, it was the kind of loving description with which this chemist Wade described his final product where he held the flask up and shook it and saw this, all these wonderful glints, these pieces of liquid jewellery.

So it was a sort of, interest in the substances that could be...?

And their properties.

Mm.

Yes. And that's why I still read that thing.

[35:44]
Mm. OK, thank you. You also mentioned Soddy's book on radium?

Yes.

Frederick Soddy's inquiry.

That was a bit later. I would be, how old would I be then? I should think, about, twelve perhaps? Still pre-puberty, but, in that sort of, twelve plus or minus one, that sort of age group. I remember reading it right through one hot summer when I was sent... They always sent me away from the shop for school holidays, partly because the local doctor, a very nice man that used to make his house calls on a bicycle, Dr Wise... Frequently in the wintertime, my mother suffered badly from bronchitis, and so did I. It was just the awful atmosphere of the place.

Mm.

We must have been tough to survive it. But anyway, he said, 'For God's sake get that child out into the country. Try and raise him here in this awful atmosphere, no good will come of it.' So they did, they compromised by sending me to, anywhere that could take me. Sometimes my aunts, and sometimes, Leith Hill. Because that was a place that my father and I used to go for walks to on Sundays, and I, I said, because I had suffered from being sent to nonconformist farms in East Anglia which had dull countryside, and dreadful people, [laughs] I say dreadful, they really were, and, couldn't, couldn't they find somewhere here? And so they enquired, and there was a Miss Saunders who had a house in the village. I, I think she was the school caretaker. And I used to go there for my summer holidays. She was wonderful, it was a very nice environment.

[End of Track 1]

[Track 2]

Now, what I'd like to ask you about now is, one thing in particular, but I think it will link with time spent with your father. You mentioned just before we stopped the recording that you were sent away during summer holidays, and one of the places that you went to was farms in East Anglia, and you describe the landscape there as uninspiring in some ways, and then, you talked about another place where you sometimes went in the summer holidays, to Miss Saunders.

That's right.

And talked about the landscape around there. And so that raises the question of, what you at that age valued about the natural landscape, what kinds of landscapes you liked, what you liked about them, how you explored them. Could you tell me about that, starting with the, expanding on the comparison between the landscapes of East Anglia and the landscapes of elsewhere that you valued more?

OK, but there's one bit comes before that. I think I... My urge to get into the countryside was almost a survival instinct. I knew that the atmosphere of London in those days, with the coal smoke, was toxic, and, the countryside seemed so much cleaner, clearer, pleasanter, that I was deeply attracted to go to it. But, I was sent away to farms in East Anglia. One I remember most clearly was one at a place called Black Bank, [laughs] named, it was in the Fens, just north of Ely, on the, the railway line that goes between Ely and March, yah I think it's March, yes, Manea, Stonea and March were the stations. Black Bank, Manea, Stonea and March were the stations along that line. And this was a kind of smallholding, that was actually below sea level, of very flat fields that I think had sugar beet in and, that were almost subsistence farmed by this family. And, the father of the family was the leader of the local chapel in the village of Little, Little Downham was it? Something like that. Just, just about, I suppose it's a mile and a half from the farm. And, they were very rigid indeed. On Sundays you were not allowed to wear anything but your Sunday best clothes, whatever they were. You had to sit in a chair, and only thing you could read was the Bible. And there were three visits to the church, or chapel as it was then, with the same exceedingly boring [laughs] hymns and exceedingly boring sermons.

It, it was repressive and, and horrible in all sorts of ways. And the countryside seemed to reflect it. You could just look for miles and hardly see a tree anywhere. And, there were embankments every so often, and when you went up the embankment, quite high, there, it was the, the old hundred-foot drain as they called it, with the water that was being pumped out to keep the land above suitable for planting crops in. It was a dreadful area in many ways. And that sort of countryside didn't move me, and I was almost glad to get back to London from it.
[03:54]
Leith Hill, where I went to see, to Miss Saunders' cottage, in Coldharbour, the, the village of Leith Hill, was an entirely different place. That was my idea of beautiful countryside. Well it still is, it's very much a preserved bit of, away from south London. But in those days it wasn't an isolated oasis of nice countryside, it was, everything around, you could walk on from Leith Hill and it was all the same. Wonderful heathland. It's amazing. Most people forget that you could walk from London to Portsmouth in the old days, before World War II, and hardly come across a farm. It was all heathland of one kind or another. There were tiny little farms in it that might have a couple of cattle that were milked for the local village or the family, but, there was nothing like modern farming. That was all introduced in World War II when we had to...

Mm.

So the countryside was totally different. It was natural.

[05:00]
You, you gave a very good visual description of the, of the East Anglian landscape, embankments and the fields full of sugar beet. I wonder whether you could pick a particular view in this Leith Hill area, and describe what you liked about it. You've talked about the... You've said what you liked about the, the ability to roam, the lack of farms, and the heathland. Is there a particular view there that you liked?

Not really. All of the views around there were good, and they were all different. I remember for example, my father used to take me on Sundays, we would... It was a complex journey actually. We would take the tram, which went past the shop, and

they were fairly frequent, all the time, and go along a short distance to Streatham Common station I think it was, and get on a train there for Dorking. And at Dorking we would change for a train that was going, a steam train that was going from Dorking to Horsham. And it stopped at Holmbury St Mary, I think it was probably the first stop outside Dorking, about three or four miles away. And, we'd get out at Holmbury St Mary station. And, within, oh, a matter of yards one entered a gorgeous field that was full of buttercups and daisies in the spring and, really colourful. And then, off up the, the climb to the, to the village of Coldharbour which was 800 feet up, so, it's quite a nice little climb, up through woods and heath, all the way to Coldharbour. And it was a gorgeous walk. And that used to be our, part of our Sunday's outing. Quite often we'd go well beyond there, up to the top of Leith Hill, which is I think, at the top, just under 1,000 feet, and you could see, it had wonderful views right the way down to the south coast and back to London and so on. And, it was pine trees and heather, and it had wonderful smells. It was full of wildlife of all kinds. I remember there was a stream ran down from one part of Leith Hill further down towards Abinger Hammer, and, my father showed me how to tickle for trout in it. And, you could... I was so amazed that you could actually catch one of those lively fish by slowly moving your hands up under the bank.

Well could you expand on that method of... Many listeners to, to this, won't, won't know what the method of tickling for trout is. Could you describe what your father taught you to do?

Yes. Well, you're in a stream, not very wide, it would be, about twice as wide as this gap here, well that would be what, about...

Two, two metres, just less than two meters?

Yes, about... That sort of thing, yes. Fairly fast-flowing water. And, twisting in and out, so, there would be a bank where there was a tree with roots, so, there was a gap underneath. And, he would say... He seemed to know, he said, 'There'll be some trout under there.' And, you got in the water very slowly, and you stayed in the water for quite a while, and then you slowly moved your hand up under the bank and raised

it. And you suddenly felt a trout. And if you could close your fingers quickly, you'd got it.

Ah. Gosh. So it requires a particular kind of, knowledge of animals in the landscape, in order to, in order to...

[08:51]
That's right. Well as I said, my father was a wonderful amateur ethologist, that his appalling childhood had forced him to be. Because, he was left one of, I think it was about thirteen children, when his father died. And of course there was no social services or anything in those days. And my grandmother had to bring up all of those children somehow. And, as, I think, I don't know whether he was the oldest, he might not have been, but, he was quite senior, and he, his job was to go and get food, by any means, he couldn't get work, there wasn't any then available, by any means possible. And he learnt an awful lot about the tricks of catching rabbits, of things, to keep the family fed. And, I remember him telling me once, a farmer who wasn't too unkind, to... because they were pretty rough on anybody who was poor in those days, you don't... it was your own fault, [laughs] it was always regarded, or a visitation for the sinfulness of the family or the father. And... But he, he let them have some turnips from his field, and he said, what awful food it was, to try and live on turnips.

Mm.

[10:10]
And, I mean, it always used to make me very cross in later life, when I heard the Irish always rambling on about how bad it was for, how badly they were treated by the English, and I thought of my father as a typical Englishman. [laughs]

Mm. Yes.

It was not so simple.

Mm.

It was a different world in those days. And, Ireland was part of England after all.

Mm.

And, their sufferings were magnified of course but they were very similar to those of my father's family.

[10:45]
Mm. Are you able to remember other ways in which your father taught you to, either see the landscape in a particular way, or to engage with it in a particular way as in the example of the trout?

Well he taught me all the kind of berries there are to eat, and about the earthnuts. I bet they've all forgotten earthnuts. There's an umbelliferous plant, I, I daren't go for it now. I didn't know it then as a child, but this umbelliferous plant has at its roots a kind of tuber which is very like a hazelnut, very pleasant to eat, but, [laughs] it doesn't look all that different from hemlock water dropwort, which is one of the most poisonous plants there is.

Mm.

But he knew [laughs] which one to go for. And, things like that. Another one was, he showed me that, yew berries are fantastically good. Now most people would run a mile from yew berries as deadly poisonous, those brilliant red berries, but if you, so long as you spit the stone out, the flesh on the outside just tastes like honey. And it's very very pleasant. And things like that.

Mm. Did he, did he engage with the landscape in a particular way, in other words did he take with him, I don't know, binoculars or maps or, did he poke around with a stick, did he go up to things and look at them? Did he sort of, move through the countryside in a particular way because of his knowledge of it, do you think?

I'm sure he did. But, don't forget, he never went to school. He, he was, until he went to Battersea Polytechnic, illiterate and innumerate. And, he had to teach himself both.

And he was never, how can I put it, fluent in the way that somebody who picked it up in childhood was. I used to watch him when he was reading a book and he would mouth the words as he read.

Mm. Mm.

And, so, maps, anything like that, would have been right outside his universe. He went, he saw the countryside through his eyes and, the memory in his mind, of what things were. But he had, he was passionately fond of gardening, and his greatest ambition in life was to be a head gardener at some big estate.

Mm.

That, that would have pleased him enormously.

[13:20]
Mm. And would you like to say anything further about your, the kind of, the history of your dad's relationship with the land and the origin of his kind of, natural country knowledge?

Well I see my father, from probably about seven or eight onwards, going out into the countryside in the way of a hunter and gatherer, way back.

Mm.

Looking for food. Looking for all... Going, learning from all the signs on, on the land, which was a root to food. And, he was successful in doing that, because he survived and so did his siblings, who were possibly doing the same kind of thing, and, despite the difficulties of the times. But it, it was bound to come unstuck at some time, and as he approached puberty, the teens, he grew more daring, and I think it was, that was the trouble, and he wandered off on to the, one of the lords of the manor's estate and got caught by gamekeepers, poaching, and he was sent to gaol for six months, that was the mandatory sentence in those days.

Mm.

Hard labour that was for, for poaching. And, he was at Reading Gaol, interestingly, about ten years before Oscar Wilde. [laughs]

Mhm.

And, he didn't like it at all, said the treadmill, they had to go on the treadmill all day, that was part of the... That's, imagine being on an exercise, walking machine that you have in hospitals, but for, for twelve hours during the day.

Mm.

It was a ghastly business. And on very little food. So, when he came out of there he thought, no, this life is no more for me,' and ran away to London.

Mm. You said that you remembered him going, from the age of seven or eight you remembered him going out in the, in this way of a hunter-gatherer.

Oh not, not... No. That was not my memory.

Ah, yes.

I'm saying, I can imagine him from about seven or eight.

Yes.

When he was put into the position of being the eldest son, or one of the eldest sons, and having to fend for his family, going out in the way of a... No, that's my imagination, sorry.

Oh yes, no no.

But it, in, in reality that's what he was doing.

Mm.

He **was** being a hunter-gatherer.

Mm. Did he, apart from being able to locate trout, being able to identify edible...

And rabbits.

How did he, how was his knowledge of where animals were in the landscape communicated to you on your walks?

Oh, tracks. He would point out the tracks of all the various things. I mean that's, that's where, that's where its burrow will be, and that.

Mm. Mm.

And, he taught me also patience, that if you want to see them, you've got to be very still and quiet.

Mm.

And get downwind of them.

Mm.

And that sort of thing. And he was never... He had built up all of this knowledge, and he was an intelligent man, and he wasn't having to learn the three Rs [laughs] or anything else at that time. So it became quite intense for him.

Mm.

And, I was very very privileged. It was like being brought up in a way by one of the original Red Indians if you like, or anyone who lived a hunter-gathering existence.

Mm.

And, it, it's a, a special kind of experience that I don't think you can ever get from merely reading or...

[17:03]
Mm. Yes. Thank you. Now, primary school, or, or your first school, there was no teaching of science, we know that from your autobiography.

Mhm.

To what extent was natural history taught there?

I can't remember, to be quite honest.

OK.

It wasn't... The, the teaching was by no means restricted to just the three Rs, although they played a major part, and they were very well taught. And, one thing did come to me since my autobiography. The, the first teacher was not at all desirable. She was an embittered Irish woman called Miss Tierney, who was over-fond of the cane even for children of six or seven, and, she would beat us on our, on our hands, you had to put out your hand to be caned. It was quite painful. And it did, I don't think it really helped the learning process very much. [laughs] But, strangely enough, under her tutelage, I remember so vividly sitting back in the class, and they were going through the, the phonetic reading of things, and suddenly it all started coming together, and suddenly I found myself reading. It was, it was such a, a revelation, it was like one of those things that, like that I told you about, my first experience of existing, it, it was, 'Oh so this is reading.' [laughs]

Mm.

And it filled me with a sense of wonder, and I started from then to devour anything I could get my hands on to read.

Mm.

I didn't want, you know, Mary and, what, [laughs] whoever else it was in the silly little tales. I wanted the hard stuff if you like in reading. And that's when I went to the adventure books and things, and comics.

Yes. Thank you.

And I think comics serve a useful process with kids, in that sort of stage, in, in getting them to read.

Mm. Were there any particular, do you remember liking particular sorts of comics for any particular reason?

I don't think I can remember the names of what were the common ones around those days. But there were kind of, archetypical figures, like some character called Dan who was the cowboy, rather disgusting habits that we used to laugh about a lot, that was always getting into trouble. But, no, I can't, can't really remember.

[19:39]
And was there any popular, popular science at that time on radio or in magazines or, encyclopaedias, that you...?

No. Only the Science Museum. That played a huge part in my early days in science training. And it all happened because, my mother and father both wanted me to go into the arts, preferably to be an artist or something like that. Because I did have a little bit of talent at drawing, so they thought this could be developed. And, so they took me to the Albert and Victoria Museum on Sundays and to the National Gallery and places like that. And I was not much moved. It, it didn't seem... And then, when we went to the V&A I saw the Science Museum. Of course, I don't know whether you've ever been there from a Tube station. You see we went on the tram from

Brixton to Victoria where there was a clock tower in the middle of the road (it's long gone), and, got off the tram, that was the terminus, and walked down to the Tube station, or the Underground station it was, and it's two stations along, Victoria, Sloane Square, South Kensington. Got out at South Kensington and walked along, a rather mephitic tunnel, like an extended old-fashioned public lavatory [laughs] that goes all the way to the museums. And, they dived off up one thing. And I said, 'Can't we go ahead, because it says the Science Museum, I'd like to see that.' I wanted to know what it was. And they said, 'Oh well you go on your own and we'll meet later.' And, we, we arranged to meet, I think it was at a teashop in South Kensington itself, at a fixed time, I've forgotten when. So they had their afternoon at the V&A and were happy, and I had mine at the Science Museum and was, I loved it, it was, it was terrific.

[21:36]

And first I went for all the mechanical stuff in the ground floor, great big steam engines and all sorts of things, and you could press a button and it worked. That, that was, was terrific. But then I began to wonder what was on the floors above. Because I don't think it was that big in those days. And I came across one gallery that was about mining, [laughs] and they had... they, they were completely unthinking in those days, pictures... not pictures, sort of, simulations of sticks of explosive and detonators and things like that. And, as a potential young terrorist I absolutely lapped this up, this was fascinating stuff. If only I could get my hands on this, what fun we'd have at Guy's Fawkes Day. [laughs]

Mm.

It was a cornucopia of delights, the Science Museum, and I wandered around all of it.

[22:31]

Do you remember other exhibits in particular?

Oh I remember the... They had an exhibit about dangerous drugs, and, they had vials with crystals of morphine, crystals of heroin and, cocaine and various other things all up there. I was fascinated by this. And the descriptions of the terrible things that would happen to you if you took them. [laughs] And so on and so forth. And then

there was on the top floor a physics section, which I found wonderfully fascinating. They had a giant, it must have been Victorian, polarimeter, that was, there were great big round cut bits of Iceland spar, you know, do you know the stuff, calcite It's a birefringent, and it will rotate the plane of polarised light. But unlike most polaroid, it's not coloured, it's transparent, it looks like a sheet of glass. And, you could turn the, one of them you could turn, and in between were things like sheets of mica and various rocks. And of course it went through all the, amazing colour, colour frequencies as you turned the polarisation angle. And, I found this wonderfully fascinating. And there were all sorts of other exhibits up there of simple physical things. And they had a Van der Graaff generator at one time that produced huge sparks.

[23:58]
Mm. Any, any that you can remember in detail, could you describe for the recording? Because this is fascinating. You know, the memory of the, the Science Museum at this time, which was probably, what age were you visiting at this sort of time, using the, using the exhibits and pressing buttons?

Well I went there regularly.

Mm.

All through my childhood, up until the time we moved from the shop in London to Orpington, so that would be from, from about seven till sixteen, that... Would it? No, not sixteen, it would be about thirteen. Seven to thirteen. That's... It seemed a long time to me in those days, but of course that's what, about seven, six, six years. Not so long now.

Mm.

And I also went afterwards, I don't know how I got there, but I used to go in afterwards. I think I've told you the essence of the things. There were of course galleries with simple aeroplanes in, and more advanced ones, and models of airships and things like that. But that never excited me quite as much as did the... I've always

been a small-scale hands-on person. My inventions have nearly all been small detectors and devices rather than giant machines and things. I'm not really into the giant machine business, so, it was the small stuff that... I suppose if I'd been engineeringly inclined more, I would have become a jeweller or something like that rather than a...

Mm. And the Van der Graaff generator, do you remember the appearance of that as a physical object in the museum?

Yes. It, it was a fairly simple one. It was a long cylinder, presumably of some insulating plastic material, I don't know what. The common one used in those days was a thing called Bakelite, which was a primitive, phenol-formaldehyde resin, I believe, but I'm not sure, I might be wrong on that. And then there was ebonite, which was a form of rubber almost. But whatever, ever they were, it was a long cylinder and on the top of it was this big ball, and, you pressed a button and it started glowing and sending out huge great lightning type sparks.

Mm.

Very impressive.

[26:20]
So this is the late Twenties Science Museum. They do seem to be set up for the interaction of visitors at that time.

Yes, and it was single... This was an enormous difference. The grammar school I went to, which was not a good grammar school, they did not have school parties that went around the museums. No, they let you go there on your own, let... You had Wednesday afternoon was one of the options. In the summer one joined the rambling club and went out into the country, which I did. In, in the winter, it was to the museums. And you went to a museum, it could be of your own choosing, and, then you had to just write a brief little report on what you saw, which was no, not at all onerous for me.

Mm.

And it was a, a nice way of keeping up with the Science Museum. I, I deplore the school parties they have nowadays, I think they're totally mad. You see them at the Science Museum and they're noisy, they spoil the atmosphere of it for the quieter child who wants to enjoy it. And, they're not learning anything; they're just playing, kid games, human games.

Mm.

Working off each other.

[27:41]
Mm. Mm. Thank you. Now at the, at your secondary school, or at the stage that you're at your secondary school, in your autobiography, there's two sorts of descriptions of your sense of self really. One is of yourself as eccentric. I wonder whether you could expand on your sense then of yourself as eccentric.

Well I don't think as a child you ever have any feelings of self in that sense at all. Maybe I'm wrong, but, you, you're just in an environment in which things are happening, and you respond to them. And there's people around you that respond in different ways, if you do... It's, it's, it's almost indescribable. It's not the kind of world of an adult.

Mm.

Do people forget this, can they not go back to their childhood somehow...

Mm. Or...

...and remember...?

Perhaps it's about your, the way that you saw yourself in relation to other people around you of your same age.

Well they were either good or bad. [laughs]

Mm.

You didn't really go into it. Or, or indifferent.

What about the, your sense then that you wanted to become a scientist, no matter what it took? Now you've, you've mentioned that your mother and father were keen for you to become an artist for example.

Yah.

In feeling at that age that you wanted to be a scientist, what at that age did you, can you remember, you felt that being a scientist involved?

It involved a life in which you had a plethora, a cornucopia, of all these marvellous things that there were in places like the Science Museum to play with indefinitely. [laughs] And this as a small child thing.

Yes.

What a heaven that would be, was the kind of...

Mm. And I wonder whether, was the, was liking the idea of being a scientist, was that set against alternatives, so other kinds of life that you could imagine in the future? Deciding that you wanted t be a scientist, did you understand scientist in relation to other kinds of people, such as artists, or, sportsmen or...?

Well, I, I was surrounded by art, I grew up in the shop, and painters, local painters had sold their ware there, came in and some of them became personal friends of my mother and father. So, I was well aware of that world. And, although I didn't disapprove or dislike it, it didn't seem to be the world for me. I just, there wasn't any contest, it was science and that was it. I also read in the magazines and books

adventure stories of people who... I, I liked that, and I often thought, wouldn't it be fun to go out exploring somewhere and, climbing mountains and whatnot. And later on when I was older I was able to do that. But, it didn't, I didn't see that as a full life. I think it was more, one was practical. You knew that one was limited and constrained by the environment one was in, and there was just no escape from it.

Mm.

And that was the end of it.

[30:57]
Thank you. Could you expand, you may not wish to, but if, if you do feel inclined to, I wonder whether you could expand on what I see and what I think other people reading your autobiography would see, is the, the fascinating sexuality of the Strand School, both in...

Oh yes. Yeah.

Both in terms of, you know, the, the story about the French lessons for example...

Yah, that's right.

...and the boys there. There's that. But also, the, the masters' relations with boys.

Mhm.

I wonder whether you would be able to expand further on that particular kind of sexuality of that school.

It's interesting, because, it's, it's always puzzled me. It was about as frankly sexual as any place could be. There were no inhibitions anywhere. But... And this is puzzling, because as soon as you got outside in the world, one was surrounded by intense inhibitions of society as to what you could or couldn't do. Mostly enforced by women by the way. This looking back on those times. The men never seemed to be

the enforcers of strict, correct behaviour in that sense. [pause] The first I encountered it was in the very first form I was in at the grammar school. Perhaps I should just interject here. I went to the grammar school at nine years old, which is ridiculously young, because, my mother was living through me, her failure, and here was the chance to go to grammar school. You, in those days you, at that age you had to pay to go, and she could afford to pay, and so, she, she thought this would be the great thing. I was quite willing to leave the primary school, where I was very happy, it was almost an ideal atmosphere, and go to the grammar school, because I thought I'd learn science there. And, so I was put in the first form, which was run by a man called the Reverend A C Digby French. And, I've forgotten what his nickname was, but, probably something very, very fruity. Now he was a mild pederast, nothing very severe. He used to like young boys to come and sit on his lap, and he would encourage it.

Mm.

And we all somehow knew. And, there were those that did and those that didn't. There was no compulsion, there was no sense of threat. No sense of worry or anxiety amongst the children, either those that had sat or those that were, didn't. It was all very harmless I would think in a way. But probably what goes on in an unrestricted atmosphere anywhere, any time, as a proportion of, of men who are like that, have a sexual attraction for young boys, and, they're sufficiently civilised enough not to carry it too far, and they just... It's a bit like the kind of nightclub where they do what they call lap-dancing. I was taken to one once in Amsterdam, and I found it utterly revolting. I could not see the point of having young girls almost naked come and sit on your lap. I mean, as far as I'm concerned, sex is definitely tied to a close relationship as part of the expression of that, that relationship. And, and the idea of just having some strange woman you don't know come and sit on your lap, it, it was embarrassing, unpleasant, not... I couldn't see the point. And the same I think is true for most people with young, for the men with the young boys. It was all, all seemed rather pointless and...

[34:57]
Did it go any further than just boys sitting on his lap?

I don't think so. No. We talked freely amongst ourselves, and I think if anybody... If he had tried to take their trousers down and, try for buggery or anything like that, it would have been around the school in five minutes, because, [laughs] 'Do you know what Sir did to me?' kind of thing.

Yes.

There wasn't, there wasn't any, or there'd have been yells and screams. I don't... No, I don't think that happened at all.

And other teachers?

The... I don't know of any other teachers who were like that. He was the only one. And he had, interestingly, taught the youngest kids.

Mm.

And, I think those past puberty would have given him short shrift. But, no, it's a... [pause] That, that's as far as that first bit goes. Now the, the later bit... Let me think. In between. As soon as one reached puberty and masturbation produced semen, then, boys discussed this with each other at some length. And, in fact, there used to be, semen was referred to as spunk amongst kids, and I found it intriguing in America the word means courage.

Mm.

[36:26]
The Americans seem to be entirely unaware of the, of the language difference there. It's a bit like bugger in America was a, never understood, and you would get respectable Bostonian women of middle age talking, referring to your boy kids, 'Oh what a cute little bugger.' [laughs] Didn't call the police. [laughs] You realised it was a language difference. No, it, it was all fairly open. It was part of life, there was no... And you knew you couldn't talk about it to your parents or anybody outside;

this was our world, the world of the schoolboy, in its own special world. And, I think, monosex schools are very interesting that way. A thing... What I found was extraordinary was that young boys at the primary school I went to had that queer language. If you were in a little fight, and you wanted to back out, you said 'Fanites'.

Really?

And this was a word that was in common usage and it was in the Strand School. And, somebody wrong an article on it long ago, and it goes right back, I think to Roman times. And this language, it's got a lot of, there's quite a few words in it, it's quite a study he did, you lose, when you, when you pass puberty and enter the, the sort of mainstream of, of life, but it exists in that world that the pre-puberty child lives in. And it... I, I feel, I'm amazed that much more hasn't been made of this.

[38:15]
Mm. You mentioned that, in the book, that, was it that a whole class of boys would masturbate in a particular lesson?

Yup. That's right.

Was that sort of a, a regular, every, every class of that teacher?

Sure. Yeah. Mm.

And, you...

That's why we called him Sappho, that was his nickname.

What was his reaction to that?

He didn't know.

Oh. It was all sort of covert...

That was why. He was a dear old boy, bald-headed, very... He... If, if I were to, to guess his politics, it would be somewhere in the middle of the Liberal community. Full of do-gooding, well-intentioned, and, everything in the world was nice and, you know, Dr Panglossian.

Mm.

And, never known to even chide a boy, yet alone cane or anything like that. And, taught very badly, he taught French, and read from a textbook and we supposed to follow with... Well nobody did. They just took no notice. And he never saw they took no notice, and, that was what entertained them during the time. And it was mutual masturbation. Now, the interesting thing, this was the fourth form, so they would be about, thirteen to fourteen years old, and just about, round about... well it would have been past, just past puberty for the, for the majority of them, but, nobody could have called it homosexual. It wasn't.

Mm.

They, they just engaged in it. Not all, not, by no means all of them. I mean some didn't. I didn't, because, it, it... I wasn't turned on by the thought of somebody else manipulating me. But others were. And, that, that's how it went.

[40:20]
Mm. Thank you. You said that having moved out of this particular community of the school, where there was no, or little, inhibition about sex...

Mhm.

...that in the general world there was, and that it was mainly enforced by women. Could you expand on that sense that you had?

[hesitates] Difficult really. I think because it goes back to earlier on. When you're in younger childhood, if you were found masturbating, I know my grandmother came into my bedroom one night and I was and said, 'Oh you mustn't do that Jimmy, it's

dirty. It'll lead to troubles in later life,' all sorts of, typical lecture. And, that, there was that kind of mild enforcement that went on. And, the whole atmosphere was negative so far as any kind of exposure was concerned, or, questioning about sex also. I mean, there was a complete wall of silence when I asked, when I was round about nine to ten years old, where did babies come from? It was all, a most amazing wall of silence. Nobody would tell me.

Who did, who did you ask at that age?

[laughs] Anybody I could get hold of.

And if you asked, when you asked your parents...

Parents, that's right.

...what did...?

Oh they, they would put it off. They would dodge out of the, any answer.

And your grandparents?

[41:54]
The same. And, I remember I was, when I, I first began to come to, [laughs] found the answer, well it came to me just from simple logic, was when I was at Leith Hill, and that led to an intriguing incident. I was on a holiday there, just about the time, that would be when I was in the second form at school, and I had just sat the supplementary junior county scholarship, which I won, fortunately for my parents, because that was in the depression times. And, I was there on holiday, because I'd had pneumonia, that's right, and the doctor insisted I was sent for convalescence to, away. And I was there. And I remember asked the kids around about it, and there was one girl who was very forthcoming, said, 'Oh I'll show you where they come from. You come with me to Sandy Hollow tonight and I'll show you.' And like a fool, I mean you're so innocent when you're young at that age, I told Miss Saunders. Oh boy, was there a ruckus. [laughs] That poor girl, she must have regretted that...

So you never, you never got to go to the meeting? No.

No, I didn't get to go to Sandy Hollow, no. [laughs] But, I, I just... But then, then it became obvious to me, oh well it's... what's happening, it was just simple logic. And... But I couldn't really understand what all the fuss was about.

[43:27]
Mm. Now I think might be a good time to ask about, one place where you went on your holidays, I know that you went away on all of your school holidays...

Mm.

And one place you went was, relations called the Leakeys.

Oh yes. Yes, very much so.

And I wondered whether you, you were able to, you would be able to contrast the, the wall of silence about matters of sexuality that you experienced, in terms of your parents and your grandparents, whether you could contrast that with your experience of this different family, the Leakeys, on holiday?

Ah, well, you see, you need a bit of background here. My grandmother had four daughters, and they were extraordinarily good-looking, and, had very considerable personality and presence. And all of them except my mother married very well. I think my mother was one, the difficult, obstinate child, like my eldest, well she isn't really. No, but, not so different from my own eldest child who, [laughs] married not, not too... married for, not too suitably at all. She, she was very unlucky, she married a psychopath who beat her up, but... Anyway, poor Nell went and married this ex-jailbird, [laughs] well he wasn't really, you know the kind of thing. But not, not of the top flight, and certainly somebody who collected coins in gas meters. Straight working class, no, nothing special. Whereas they all married into very comfortable, middle-class lives. My Aunt Florrie in Hitchin married a shopkeeper, was quite wealthy. My Aunt Florrie married a New Zealand executive in the Imperial Tobacco

Company, who was exceedingly well off, I think he must have been a senior manager or something like that. And they were, they immediately emigrated to New Zealand. And my other, the youngest daughter married Hugo Leakey, who was of the famous Leakey family, you know, the, the Kenya anthropologists and people like that. And they were very middle class. Old Papa Leakey was a, a millionaire, I suppose he'd be nearly a billionaire nowadays, in those days, very rich, and very privileged. Now, Leakey, Uncle Leakey, he was, Hugo Leakey, had had a job as a teacher at Dulwich College. He didn't have to work, but he felt he had to, you know. And, he caught pneumonia in, some time then. I think, the air of London was so awful in those days, you would get, chest diseases were rife. And, so they all moved to Tangier, and stayed there for quite a few years before coming back. So I missed the Leakeys at that time when I was exposed to sexuality in school. Because they would have sorted that in no time for me. And, I... But I used, from then onwards, when they came back, I used to go and stay at their houses. They, they first of all moved to Letchworth, and whilst they were in Letchworth they had a house built, a new house built, a very avant-garde house of, very classic, 1920s design. It would probably be highly listed now. It's still, it's still there in Welwyn Garden City, and, it was a very modern, a very pleasant house. They had a flat roof, and I remember they used to all sunbathe naked on the roof there.

Mm. And could... I wonder whether you would be interested in expanding on your view of the, the daughters undressing, or was it... I think there was, Mary and Jean? Perhaps they were the daughters of friends of the Leakeys.

[pause] Oh no, no no, they, they were friends, daughters of the friends of my Aunt Florrie in Hitchen.

Ah.

And, they were the first ones that turned, turned me on to falling in love so to speak, if, if it was a serious affair; I don't think it was really. But they were the, you know, my dream girls in, in the younger school days, grammar school and sort of, fourteen onwards. Nothing ever came of it, but, it often, it was the way in those days.

And do you remember how you felt about naked sunbathing, given a rather different ...?

I never saw them naked, no, that was Kit, Kit and Hugo's house. They used to... I think they were just naughty. They would take a young boy like me and thoroughly enjoy getting naked and some, friend of the family's daughter along also, to see what happened.

[48:48]
Mm. Thank you. Now, I think we ought to move on and...

Yes, we mustn't do too much on sexuality and... [laughs] I don't, don't mind it, not in the least, but I wouldn't like it to be the whole story, [laughs] if you know what I mean.

[End of Track 2]

[Track 3]

Could you tell me please about your, your first job, in 1938, your apprenticeship with a firm on the Fulham Road, please?

Yes. I was rather late leaving school. Strange, since I didn't like it very much. I, I knew, I was so determined to be a scientist that I had to get the equivalent of a university education somehow or other. And I had worked it out fairly well in my mind that the only course of action open to me was to pass the A-levels at school as they, they weren't called A-levels in those days, it was the Higher School Certificate it was called. And, you were forced at the school I went to to take chemistry, physics and pure and applied mathematics. Well I, I knew the chances I would fail on the two mathematics were fairly high, and when I sat the, the School Certificate, Higher School Certificate exam, I did. I got Distinctions in physics and chemistry but failed in both mathematics. And I thought, oh there's only one thing I can do. You could then take the London University's external, well Intermediate examination they called it, three months later. And I did three months of swotting. And it was very pragmatic swotting. I knew that I would not be able to solve the examples, because I was too slow, and exams are based on time. The fact I could solve them, and fairly effectively, was neither here for there. If you can't do it in time, you don't pass the exam. So, I knew that fifty per cent of the examination question was the theorem, knowing about that. So I memorised all of the theorems that would be required for their, both, both mathematics, all of that, and knew that I could get a fifty per cent mark, regardless. And any luck I had solving [laughs] the problems would, would be nothing but bonus. And then I passed, and got it.

Mm.

[02:17]
So, having passed that exam, I left school within a month or so, and started looking for jobs. I... Well I actually started looking before I left school, you were allowed to do that, and, went to a number of firms in London that would take on a technician who would, you know, do routine analyses or something fairly dull. [inaud] didn't like it very much, and turned them down. And they didn't pay very much either. A

typical wage would be twenty-five to thirty shillings a week. Sounds nothing now, but then, that wasn't all that bad, but it wasn't enough. Because, the purpose of my getting a job was, I had to support my mother and father, who were both now retired, and they had contributed quite a bit to keep me going and to further my ambition, and, it was my duty to pay them back. And I was quite happy about that, that seemed fair and just. So I was looking for a job that paid a bit better.

[03:24]

Then along came an ex-schoolboy called Tyrrell, I've forgotten his first name, his surname was Tyrrell, and he was looking for, the firm he worked for, this firm of consultants, for a bright lad in chemistry. And, the chemistry master was one of the few rare good masters. Strangely he was a slight outcast in school, in the school, because he wasn't from Oxbridge. He was... But he did have a PhD in chemistry, he would have been, gone to London University. And, he recommended me to this chap, Tyrrell. And, I soon found myself with a job for the firm Murray, Bull and Spencer's, who were consultants in the photographic industry.

[04:14]

They dealt with everything from gelatine that was used to make the photographic emulsions, all the way up to the dye, synthesising the dyes to be required for colour photography. So it was a pretty broad range of science going through chemistry, physics, cooking, [laughs] almost everything. And, so he had a very strange way of going about it. They paid very well. They paid £2.10s a week for starters, and if you lasted three months, they raised it to £3, which was a jolly good wage in those days.

Mm.

[04:49]

I mean, a working man would be pleased to get it. But, they made it clear, you had to go to evening classes, it had to be Birkbeck, it couldn't be anywhere else, because that was a proper London university college, and the moment you got your degree you were out of a job. [laughs] So, the leader of the firm, Mr Humphrey Desmond Murray, said, in a sort of fruity, George Sanders kind of voice, 'We can't afford to employ graduates here. We take on young lads and train them up, and you're one of them.' [laughs] 'What do you think?' I said, 'Great. I'm quite happy.' Because I knew once I had a degree it was up to me to get a job somewhere else. And, so, I

started at Murray, Bull and Spencer's on the Monday. And it was hands-on, right from that point. And he said, 'Tyrell[ph] tells me that you, when you were at school, did the unusual thing of trying these new spot tests that Fritz Feigl has invented.' And this was an analytical procedure that was done, instead of in large quantities in test tubes and flasks, in, in a tray, a big, great big porcelain tray which had little hollows in it, and you put a, only about a cc of reagent or even less in each one of those, and you can pick up all sorts of things that way. For example, one of the important ones for them was the amount of sulphide there was in, in the gelatine, because that was essential for making sensitive film, their photographic film, the silver bromide was precipitated, and if it had a little bit of sulphur in the structure, it was a bit like silicon chips, the, the silver bromide crystal was photosensitive, but it was much more so if the lattice was slightly distorted by the presence of a sulphur atom in it. It was the inclusion of small trace things. Just as they do with silicon chips, makes all the difference. So the amount of sulphur in the gelatine was an important variable in producing good quality photographs for... And it was a devil of a thing to analyse ordinarily, and these spot tests provided a way of getting, doing a sorting test for sulphide fairly straightforwardly. And, you put in a reagent, I think it was a mixture of sodium azide solution and iodine, into each spot, sorry, each depression across the thing, and then dropped your sample, small, carefully measured sample of gelatine in, and looked for the decolourisation. If there was a lot of sulphur present, the iodine was completely removed. And so you, you gradually went down the, you titrated, this way, until you got a spot where, where it was still slightly coloured. And that told you how much gelatine there was.

[07:56]

And I said, 'Oh no, I'm very glad to have a go,' and I did, and, was doing that fairly routinely, so I became quite good at it. Until, [laughs] one day, and I think I've got it, this is repeating the book, I'd been throwing the residues from the things into a beaker before washing it up. I mean this was a reasonable thing to do, rather than... And I was told not to pour the azide down the sink, because it was well known to react with the lead pipes and form lead azide which would blow up when the plumber [laughs] came to repair anything. And, anyway, that, that's what I, I was doing.

[08:37]

And then in, another test that involved mercury, I was also doing, and that happened to get chucked in to the same beaker, or rather, it was either a beaker or a small flask,

I've forgotten now, it's a long time ago, and I remember picking it up, and noticing some extraordinarily glistening, amazing, beautiful crystals had formed in the, in the mixture. Absolutely glinting in the light. And I looked up and shook it like that, and there was a most thunderous bang. [laughs] Everybody came rushing in to see... And I was holding the top of the vessel, of the glass, and nothing was left of the bottom. It just... I mean I was unhurt, but very startled and so were they, and...

Mm.

Dear old Humphrey Desmond was most sympathetic, and comforting. He said, 'Don't worry my boy.' [laughs] He said, 'I should have warned you, that azides are notoriously explosive chemicals, and strange things can happen.' And he said, 'I can't think what's happened here, but obviously we'd better stop doing this, [laughs] it's not a good way...' And, that was that. But it was a lovely incident, and showing the kind of, hands-on, nice, family atmosphere there was at that particular firm to work for.

Yes.

[10:00]
And, I was soon doing all sorts of other jobs. I went with one of their senior technicians to the gelatine firm at Luton, that were making the gelatine, because quite suddenly the gelatine had become useless, it didn't have enough sulphide in to, to be sensitive, and we wanted to see what, what on earth had happened, why not. And this was an occasion, I think this is in the book anyway, but I can tell it again, where we went around at the firm, the, this technician and I, and we talked to the foreman and said, you know, 'Show us the vat where you're cooking up the hooves and all the various things that make the gelatine,' and he showed us. And then, Riley Ratcliffe, the technician, noticed a bucket lying down beside the vat and said, 'What's this?' And, he said, 'Oh, that's the bucket that we throw the hydrogen peroxide in to the mix.' Because you have to, that's part of the instructions for the thing, it's one of the stages. And, pennies began to drop in our minds. And, Ratcliffe said, 'Well, well, it looks very new. What happened to the old bucket?' And he said, 'Oh we threw it away.' And, we checked and, and found out that what the foreman was now doing

was throwing twice as much hydrogen peroxide as before. Because, when he went to buy a new bucket, he'd forgotten, or never knew, that volume goes with the third power of the, of the dimension, so that if you reduce the dimensions just by a relatively small amount, you halve the actual volume.

Mm.

And, this was disastrous. Or rather, the other way round, you double them if you increase it.

Mm.

And, that solved the problem. But it was a lovely example of a major industrial thing where a small hands-on change can make such a difference, and where, where book knowledge can somehow be translated into practice, and become big.

[12:10]
Mm. Did you use any, or to what extent did you use instruments at the, at the firm?

We used a great deal. You see, Humphrey Murray and his partner, somebody called Spencer, were both lecturers at Imperial College, in the chemistry department, before they had decided to form their own firm of consultants. And, they, they kept associations with the university I think as well. And so they wanted to be up to date in everything. And we had some of the first electronic pH meters and things like that, glass electrode pH meters, all kinds of fanciful... and spectrometers, and things like that, which were unheard of in ordinary analytical labs around about that time, which was still working by, almost Victorian wet chemistry to solve problems.

Mm.

So, I was dragged, sort of brought right in to twentieth-century science, right as a, a youngster straight from school. And soon, got to use those kind of things hands-on.

[13:18]

Could you describe one of, one of the spectrometers as a physical object?

Yes. Well, there wasn't so much spectrometers as they were, a true term would be colorimeters. They, what you did was, a lot of chemical analytical problems required, you added a reagent to a solution you wanted to know how strong it was, and the reagent would cause a colour to develop. And this could, it could measure the acidity or it could measure the oxidising capacity, all sorts of things. But it just formed a colour. And, well, I mean you could do the colour by matching against similar coloured things, of known quantity, but that's not very accurate, you can't get better than about two to one on that. But, so what you did was, you put it in an instrument and a beam of light shone through it, and a filter separated the beam into narrow spectral regions, and there was usually a disc with a set of coloured glasses on that did the filtering, and you turned the disc round to the one you wanted. I mean if it was a yellow coloured solution, then you would get maximum absorption if you shone blue light through it, of the right wavelength. And, then there was a photocell on the other side that picked up the signal. And you got, noticed the difference between distilled water clear, which would be complete transmission, and whatever coloured solution you had. In that way you could have a quantitated measure of the amount of material in your sample.

What did the actual output look like then, if you said that it was a quant...?

It was a reading on a meter.

Oh, OK.

And you jotted it down in your notebook.

And, what would, what would then a meter have, have looked like?

Oh. Oh I've got loads of them around. I can show you. But, I don't think there's any in here. We've gone past that. We've gone into digital age. It's, a meter was, is an analogue thing, like the, an analogue watch, except that it was a panel like this, and there was a needle that went up from nought. It's like the speedometer in your car.

Mm.

An analogue meter. Except they don't go right round, most of the meters, on the instruments; they only go across about, forty-five... fif... no, ninety degrees I think it would be, be it.

Mm.

Nought at one end, nearly always the left-hand end, and 100 on the right.

And what did those numbers on the scale mean? Do you have to do something with those numbers in order to...?

Well you set it up so that when, when the light was shining through distilled water, clear, it read 100. And you adjusted a knob until it did read 100. And when it was dark, it was reading nought. And then, when you put your solution in, it reads somewhere in between.

Mm. And then, let's say you've got a number of forty-seven.

Yes.

Did you have to refer to some sort of text in order to say, something about the chemical that you were looking at, so...?

Well it depends. If, if the reading was a fairly small change between, shall we say, dropped from 100 to ninety or eighty-five, you could assume that it was directly proportional, the, the strength of the thing, to the drop in the thing. But as it went further down, it grew, non-linearity came in, and it grew less and less. And, there's a relationship called Beer's Law that you could apply to correct larger deviations for stronger solutions. But you also calibrated the thing, that, you had to do that with the, with the strongest solution you were ever likely to, to see, see what the reading was, and then, see if that fitted on your Beer's Law curve, and if it did, then, then you

could just use the curve. You drew the curves yourself on graph paper with lots of points. So, you know, it was all... and matched it that way. It was all wonderful hands-on science.

[17:24]
And the electrophotometer?

The, the which?

Did... you also had an electrophotometer? Am I saying that...? Oh, sorry, electronic pH meter.

That's right.

Could you describe that as an object and how it worked?

Oh that was rather, rather fascinating to me as a young scientist. I knew that glass was a very good insulator, perfect insulator, and here was this gadget they were giving me that was made of glass, it was a sort of glass test tube, long one, and inside was a wire, and a bit of stuff attached to the wire. And, that was one electrode. And then you would have another electrode called a calomel electrode that was dipped into the solution, and you dipped the two together and measured the potential between them with an electrometer. And, that was exactly proportional to the pH as a solution. So that you could get a read-out on your meter of the pH, that's the acidity or alkalinity of the... So, if it was neutral it would be round about seven to 7.4; if it was strongly acid it would be one or two, mildly acid like vinegar, three or four, and so on. Alkali, strongly alkali, fourteen. And, this read it. But, the, the thing that fascinated me was that glass was conductive enough. It was a special glass. This glass lets through hydrogen ions but nothing else. So that the protons in the solution, because, the acidity of a solution is really a measure of the number of free protons there are in the solution, the more, the more acid. And so, whatever number there was, you could tell the number that had gone through the glass and that changed the potential between the two electrodes.

Yes, mm.

[19:22]
Now that was very advanced stuff for those days, and got me deep in to both the physical chemistry and the, thing. I mean, what a training for a young would-be scientist. And... But above all, the most important thing that's missing at all universities practically was that Humphrey would give us lectures every so often. 'Now, don't forget, no fudging, no cheating. People's lives could depend on you giving the right answer to the problems that we set you. If you've any doubts at all about the accuracy of your results, come and see me. I would far prefer you to come and tell me you're having a problem with doing the measurements than, than you to fudge the result and give me an answer which you think will please me. It **won't**. You'll be out on your ear if there's any, if I catch you doing any of that.'

Mm.

Now, students don't have that. I mean I can remember the invigilator in the laboratory at Birkbeck for example saying, 'Well it doesn't really matter what the... that you get the right answer. As long as you understand the method, because that's what will be required at the exam.'

Mhm.

So what you learn as a student is to pass exams, not to do science.

Mm. Mm.

And this is terrible, and quite wrong.

Mm. I, I wonder... I'm just going to ask you whether there were any other instruments in the lab at the firm that we need to know about, any other sort of, these room...

There was a plethora of instruments. It was, [laughs] you know, it was an Aladdin's cave of bottles of chemicals. You've never seen so many chemicals anywhere. And, I used to have a lovely time going round sniffing them all, to, to... And I got so good, I could tell the difference between amyl and isoamyl acetate and, all sorts of tiny, small differences. A bit like a, one of these dogs sniffing for explosives. [laughs] And that stood me in very good stead when I went to Manchester University, because, one of the student tests there was to take a mixture of organic chemicals and analyse it to find what its constituents are. And I found in most instances all I had to do was sniff it and I knew what [laughs] the things were and then you could work backwards to the analysis.

[21:52]
Yes, as a shortcut. It's quite nice I think to look back from this laboratory to the teaching of chemistry at your grammar school, which presumably didn't have the sort of instruments that you had in this firm.

No, it was taught in a terribly different way. The chemistry master in the sixth form, this Dr Toms, was very good and did his best. But he complained bitterly, the others didn't, that, he was limited to what he could tell us by the syllabus. The syllabus for the exam, that was the Highers, required that you know these things, and that you can answer exam questions in these things. It was very rigid. And this was for the convenience of the academics who set the questions. It really wasn't... It had lost track of its original intention, to teach science. It was far more a matter of, of sorting the, the sheep from the goats, if you can pass, memorise all this stuff and pass it, then you can enter it. And I think it's fatal.

How in practice was it taught?

It was taught by, by lectures, by experiments. There was much more experimenting in those times, it was much more fun.

[End of Track 3]

[Track 4]

Now I know that while you were working in the London laboratories on, in summer holidays you used to cycle and walk. And, in your autobiography you mention a, you mention falling in love on one of these holidays...

Yes that's right.

...with Mary Delahunty, am I saying...?

Oh no, no, that was, came much later.

OK.

That was when I was a student.

Could you tell the story of falling in love in the summer holidays while working at the laboratory?

[hesitates] Yes. In the summer holiday, now which one would that be? Oh deary me. It's hard to pin down the precise year. It would have been, 1939, of course, the year of the war. I went on a youth hostel holiday in the Lake District, and, walked from, where would it be? I think the train went to Windermere in those days. I've forgotten the name of the little town there was there on the eastern side of the lake. I think that's where the branch line train from, where would it be, Carnforth probably, stopped, and went off to there. Anyway, got out there, and started walking straight away, going west towards Coniston Lake, and, stopping at youth hostels. I think I probably stopped at a hostel the first night near Windermere, and then went on the next day, because, I wouldn't have felt like a day's walking after a journey from Euston up to that part of the world. It took quite a long time then. [pause] Not an awful lot to say, except I thoroughly enjoyed the Lake District, and I was blessed by fairly good weather that summer. It's not so usual for that part. And I love the mountain scenery and the walking. And, the youth hostels, as always, it was a wonderful movement, that, even if Hitler started it... [laughs]

Mm.

And they, they were so well sited, in really pleasant bits of the countryside and with nice spacious houses, and a good, disciplined system. You, you did the washing, helped with the washing-up and the chores of the place, and, you brought your sheet sleeping bag, which was a wonderful invention, that you put in your rucksack, quite lightweight, and it had a kind of pocket into which you slipped a pillow that the hostel provided. And these were the sheets. And the hostel provided the mattress and the blankets and the pillow, insert. And that was it. So, there wasn't any... And you could, there were facilities at most hostels for washing out your sleeping, sheet sleeping bag if you wanted to.

I don't suppose you needed much encouragement to get out, but, do you remember, apart from the existence of the youth hostels, any other aspects of the outdoor movement, inter-war outdoor movement, in terms of encouraging youth out into the countryside, in terms of posters or, I don't know, leaflets?

I think a big difference between those times, my school days, and afterwards, and post, not immediately post-war but the more recent times, is that, things were done individually. There was far less encouragement of, and certainly not mass encouragement, but there were plenty of organisations and facilities to enable a youngster who wanted to do things on their own, or in company with one or two friends, to do so. And, I'm personally prejudiced, maybe because that's how I grew up. I much preferred... I think mass movements are suspicious always, and, doubtful.

[04:10]
Mm. And so you chose to go alone on, youth hostelling?

That's right. Yes. It, it's not easy to choose a companion to walk with of your own sex who has the same kind of endurance, same kind of interest in countryside and whatnot. And so it's always a matter of compromising, that, you can do it, but it, it's, I found it preferable to walk on my own and then, there's plenty of company in the evenings when you've got to the youth hostel.

[04:44]
Mm. We've talked about other landscapes. Could you say what in particular you liked or found interesting about mountain scenery, or mountain environments?

Perhaps it was the negative effect of the fen country to which I was sent too often as a child, that made me think that mountains were wonderful. My father was always, said he much preferred the hilly, downland country to the flat plain in, in Oxfordshire. Because he grew up in, on the hills above Wantage. And, I like to be able to see long distances. I don't like, I don't enjoy walking in woods, where you did this morning. It's not my preferred type of countryside. If, given a choice, I much prefer here, walking on the coast or on Dartmoor, which is only eight miles away. But you have to drive there.

[05:53]
I... Just as I detected a kind of consciousness of the pollution on the Brixton streets, which you say it was impossible not to be conscious of, because it was so...

Yes.

...so thick, when you're describing in your autobiography countryside scenes, like the Lake District in this period, you very often comment on air and clarity and that sort of thing. And I wondered if you could comment on that in relation to your interest in mountains and walking and climbing, a kind of, awareness of the clarity or otherwise of air around you.

I think you've hit on a very important point here. You're quite right, and, I think, I, I was happiest in environments where I could see very long distances. I love the, particularly the mountains in Western Ireland, where you could... whenever the wind was directly off the Atlantic of course it was as clean as almost you can get it then, and you could see anything forty, fifty miles away. It was a wonderful sight, endless landscape going on, breathtaking clarity. And, I didn't like it when the countryside perhaps a mile ahead was obscured by haze, which was so frequent in southern England post-World War II, but not before.

Mm. Do you remember when you first noticed this haze?

Yes. I would think somewhere in the Fifties.

[07:35]
OK. And so, on one of these evenings you, you met someone who you think you fell in love with.

That's right. And that was, let me see. I had walked on west to Coniston, and then from Coniston... I'd have to kind of search back in my mind to get back to which ones I stopped at. But it would be somewhere further over in the south. All I know is, I finished up a little bit later at the, perhaps the most dramatic of all lakes in the Lake District, Wastwater, which is on the western side. And, there are huge screes that run down, well over 1,000 feet, probably, nearly 2,000 feet, from the top of the small ridge of mountains above the lake right the way down to the lake. And, [laughs] it was my ambition to run those screes, because, they used to call scree running poor man's skiing, and it was a wonderful dangerous thing to do that young men really loved. And, I don't know whether you've ever tried it.

No, in fact I've not heard of it. Was this something that was popular at a certain time, or...?

Well it was popular amongst the hill walkers and the climbers of my time. Not many did it, because it seemed so dangerous. What you did, you had one of these enormous banks of small rocks running down the side of a mountain called scree, and, you would have a clear run of 1,000 feet easily sometimes. And, all you had to do was take a running jump onto it, and it all started moving, and you moved your feet with it in rhythm, so that you always kept ahead of the big boulders that begin to start rolling down behind you. And if you tried that in Wasdale, you might well get things as big as cars coming up behind you. So the important thing was to know when to get off, [laughs] and to run off the scree towards the bottom and then watch them all going on their way.

Yes.

Very destructive, you were probably accelerating erosion enormously.

Yes.

But we loved it, and never even thought about the, anything but the fun. And never thought about hurting ourselves, which could easily have happened.

Mm.

That's what I meant about young men in that age; you don't even, doesn't enter your head that what you're doing is dangerous.

No. Or, or even, it's sort of, part of its appeal, so...

Mm. Yes.

And, and so it was, the youth hostel after this particular...

No it wasn't that one. No. I stayed the night there. I remember that very vividly. And walked to quite a few places from there up to the top of Great Gable for example, and, the highest mountain in England I think which is about, 3.2 thousand feet I think it is.
[10:31]
Then, after that, I, I had booked up to stay two nights at, what was the name of... the Black Sail Hut. This was the shepherd's hut that was at about 2,000 feet up in the mountains on the other side of Great Gable, above the, as you're moving on towards Keswick in the northern part of the lakes. And I had arranged to stay there. And that was where I met this girl. The weather suddenly socked in, and when I arrived at the Black Sail Hut it was hardly visible. And it was a very small place. And of course they had separate dormitories then for the boys and girls. And, there was this girl from Manchester with, with a, a companion, a Jewish girl who was exceedingly nice, called Anna-Marie Cohn, who was a formidable person. I don't know whether

[laughs] the English girl took her around as a minder or what, but she would have been a very good minder. She was an Olympic shot putter I think, so you got the idea of it. But a very nice person nevertheless. And, anyway, I got very friendly with these two, and we were the only three there for two days, and we were trapped in the next day because of the weather that precluded any excursions out at all. And, they cooked the meals and were very good. And I just fell for this English girl. Her name was Lois Dickinson, and it turned out she was a chemistry student at Manchester University. And, [laughs] that was the prime reason I went to Manchester University. I mean, I was naïve, stupid, I didn't know how to start any sort of relationship. And... But, nevertheless, it was emotionally, I fell for her, and that was it. And, we moved together to the next two hostels. But nothing developed, the relationship, at all, in fact she was rather cold. Probably wasn't very interested in me.

Do you remember what you found attractive about her?

No. Proximity as much as anything, it was... I had led a very solitary life up until then, and, mainly because my home was in Orpington, and to get there meant a train journey from London where my work was, and there was very little time to engage in any kind of social activity whatsoever. Birkbeck offered big chance, and, there were certainly plenty of girls there, but I never fell for any of them. It's a peculiar thing. [pause] I, I don't know what makes one fall in love, it just happens.

Mm.

Some people never do it, I believe. But, for me it's a very positive real sort of thing. And it just happened. Anyway, when I got back to, home in Orpington, I got a bit desperate, and, sent this Lois Dickinson a telegram saying, 'I haven't heard from you in England.' And she wrote a furious letter back saying, 'Never...' [laughing] I think she probably had to explain to her parents just what... You can imagine, telegrams still had that significance to the working class back in those days, but, I suppose it goes back to World War I, World War I when the message of the death of a soldier was sent by telegram, and, they had a sinister connotation.

Mm.

Anyway, that's, it was unrequited love that drove me to go to Manchester as a student when Birkbeck closed as a result of the imminence of war. All the London colleges closed. And if you were at a regular college of course they automatically moved you to another university. Not so if you were an evening class student. And, that, that, I felt, was very unfair. In fact I started a movement, a political movement, to try and get that changed. But that, that's another story, that's separate, you've got that somewhere else.

[15:07]
Shall we... I think we'll use this young lady as a sort of narrative link to take us to Manchester.

OK, that's all right.

And, you, you went to Manchester because, you knew that she was studying chemistry there.

That's right. And I was going to study chemistry anyway. I mean it's a case, what university do you want to go to, that has a chemistry department and, [laughs] that has this girl? Well Manchester was the only one. And, that, that's what moved... I couldn't have made a better choice academically if I had tried.

Mm.

It was perfect. Because my two subjects, chemistry and physics, I was doing an honours degree in chemistry which meant you took physics up to degree level. The physics professor was Blackett, who also had been my professor at Birkbeck.

Ah.

And had moved at the same time. And the chemistry professor was Alexander Todd, who was a, subsequently became Lord Todd, President of the Royal Society, so...

Mm.

I couldn't have chosen better academically. And they were both then young, active men, not elderly professors, endlessly on committees, that their students never saw.

Mm. Were you aware of Todd's word during the war, in terms of security work, at all?

Not really, no.

Mm.

Could we then start with...

[16:31]
He wanted me to be a PhD student with him, but, because of our relative poverty, there was no way that I could do that, I had to get a job.

Could you describe the teaching of chemistry at Manchester?

By most standards, it was very good. Todd was an extremely active and good teacher. In, in certain ways he resembled our current Prime Minister, Brown. And, I think he rather lacked a sense of humour. And he was, one thing that drove him quite mad, he couldn't, he was... He wasn't a misogynist, but he couldn't stand the women students who would sit in the front row, because they were conditioned that way, and then write furiously everything he said in their notebook. He'd get so cross with them sometimes that he'd throw chalk at them, [laughs] their continued writing. He'd say, 'It's... you're wasting your time. Not a single thing that I say, that you're writing down so avidly, will be asked as an examination question. You're wasting your time altogether. And at the end of each lecture, you will receive a,' in those days was cyclostyled, it wasn't produced on the computer, 'a sheet of notes describing everything that I've told you in this lecture. What more do you need? Why do you need to slavishly write? You should be listening to what I'm saying and thinking.' And it was very good. And it applied to, to us as well, although we weren't, we

weren't of the type to write copious notes. And his lecturing was quite good. But it was on a topic of chemistry, which I found absolutely dull and boring, and that was the chemistry of the nucleosides, the, the basis that, that formed the, a crucial part of course of DNA, the structure. And he had honed in on the, realising just how important it was to understand their chemistry, and, and the way they operated and, and they physiological relationships. And of course it was one of those key steps that led eventually to the discovery of the structure of DNA.

And how in practice did he teach? I mean, are we... was it a, writing on a board and talking, or, were there instruments used to dem...?

Oh. OK. Now, what was called higher organic chemistry was what, which he taught. It was a lecture given each day from nine till ten in the mornings I think it was, with, with the supply of notes afterwards. And also supply of all the literature sources to go and look up, to, you know, read more about the topic. And, just a good, long lecture. For me it came at a time when I, I've got a fairly retentive memory and I've never had to make notes, and, enough of it stuck. But I was not interested. So, it didn't stick in, in such a way that I could easily regurgitate it well, if you know what I mean. But enough to just get by. And, as a teacher he had one, some would say a weak spot, I think it was a, rather advanced, at the end of the second year. After we had passed our sort of locally, internal examinations, they weren't very serious things, he said, 'Now all of you will get a degree.' That's at the end of next year. 'You don't, I don't want any of you swotting. I want you here only because you're interested in chemistry.'

Mm.

And, this to me was the worst possible thing to say, because I took it as a kind of, season ticket to enjoy myself [laughs] entirely for the next year, knowing that I would get a degree anyway.

Mm.

And, I was also helped by the fact that, my hands-on experience, and particularly my practical experience at Humphrey Desmond, Murray's laboratory, had made me years ahead on the practical side. And...

Did you... What instruments were you using there at Manchester in...?

Well, in, in the physical, there was some very good physical chemistry taught as well, not by Todd, that was taught by one of the Polanyis, who was quite famous. And, Nuttall, of the Geiger-Nuttall, Geiger counter, was one of the lecturers there in the physics section. And... Oh no, there was good... Most of the day was spent on lab work at the university there, not on... And you were set a, a course of assignments, of laboratory tasks to do. And, in the... I started in the second year, because I'd done the first year course at Birkbeck, and, the first part of it was right up my street which was just ordinary analytical methods, gravimetric and volumetric, which were the standard then in those days.

[22:00]

And, this is down in my autobiography, but it's very relevant at the moment. After I'd been there only, I think it was two or three weeks, I was called to see Todd in his study, and he said to me, 'Lovelock, you've cheated.' And he said, 'Look at it. We accepted you here to start in the second year, which is something we rarely ever do, on your record at Birkbeck, and you've let us down badly. Why? What on earth possessed you?' And I said, 'Cheated? What do you mean, cheated?' He said, 'Students never get the right answer to gravimetric analyses, and certainly not twice running.' He said, 'You must have looked up the results in the invigilator's book.' [laughs] And so... And Brown-like, he then didn't stop, he just went on, ranting on, and say, 'What's more, you've not only cheated, but you're a fool. Anybody with any sense that did that, looked it up, would at least have made them different, to make it look different.' He said, 'You just slavishly copied them down.'

Mm.

And then I had ten minutes calming him down, and explaining that I could do that particular analysis in my sleep, as it had been a very important part of my work for

Humphrey Desmond Murray, [laughs] measuring the, the bromide content of photographic films and things.

Mm.

And so it, it, I could do it without... And, towards the end of it, he calmed down, and he suddenly realised that, what on earth were they teaching the students there?

Mm.

Because, the invigilators would tell us in the, before the analyses, 'Now this is a very difficult analysis. Don't worry if you don't get it right. It doesn't matter, as long as you understand the method.

Mm.

Now, what's that producing as a generation of chemists, compared with Humphrey Desmond Murray's insistence, you must never fudge, you must get it right, no matter how hard it may be? And you can get it right. And we did.

Mm. What was involved in accurately getting a gravimetric result?

Mainly technique, and a persistence, and care.

For people who don't understand what that technique is at all, what does it involve?

A lot of it's common sense. You see, what you do, you've got a solution that contains a certain amount of bromide ion, it might be sodium potassium, might be any, cation, as I say. And, you analyse it by adding silver nitrate to the solution, and a white curdy precipitate comes down immediately. Fortunately it's a fairly, well a dense precipitate. It's large lumps, and it's very easy to filter off. And, you, you filter it, filter it off, and then... [pause] Do you know, I've forgotten the exact details now. I can't... I don't think you ash it with silver nitrate, with the silver bromide thing. But, you weighed the silver bromide the spin produced. And there are all sorts of crucial

little steps like, the... when you're, you've got the beaker containing the precipitate, as you're pouring it in to whatever filter funnel you're using, filter paper, you've got to make sure that none of the grains of it are left behind. And you use a thing called a policeman incidentally, it's a little rubber thing like a finger stall that fits on the end of a glass rod, and, I think they called it policeman-like because it's like a policeman's helmet, old-fashioned one.

Mm.

And, you can run that round the beaker and gradually keep washing it in from a wash bottle with distilled water until you've got every last trace of the precipitate in. Because if you don't, then your answer's going to be low. And, it's not, not a difficult technique, but getting it just right is, and it sorts out the men from the boys if you like.

[26:10]
Mm. Thank you. And for the laboratories at, at Cambridge for the teaching of... sorry, at Manchester, for the teaching of chemistry, what in those laboratories at that time were seen as modern in terms of chemistry, in terms of instrumentation or storage, what was up to date then in the laboratories at Manchester?

Not much. [laughs] It was pretty basic really. It... You see the, the organic chemistry was still, which was the main subject of the honours degree there, was pretty massive. And some of it was frankly dangerous. For example, one of the preps, that I didn't do but some of the student laboratories did, was to make, shall we say, 200 grams of diethylnitrosamine, and then purify it by distillation. Now it's a very easy thing to do, you take some diethylamine, which is a nice ammonia-smelling liquid that boils somewhere about fifty or sixty Celsius, and, you, you pour it into a large beaker and dilute it with a fair mount of water, and, make it acid, neutralise it with any, any old acid, hydrochloric, sulphuric, it doesn't really matter. And, then add a weighed-out amount of sodium nitrite, slowly, in bits, or a solution of it, it doesn't have to be weighed up. But as long as you know exactly how much. And there separates a layer, a floating layer of a slightly yellow coloured liquid on top. And this is diethylnitrosamine. And, then you separate that with a separating funnel,

which are quite big things with a tap at the bottom, and, from the watery part that's left behind, and make sure you've got rid of all the water. You dry it over a little, usually it would be something like anhydrous sodium sulphate, by pouring it through, so that you've finally got the dry liquid. And then you distil it, make, making sure that you only collect the fraction that boils at the boiling point of diethylnitrosamine, I've forgotten what it is, but it's above 100. And, and then you collect your samples and store them or do what you like with them. Now it happens that diethylnitrosamine's a potent carcinogen, really potent.

Mm. Ah.

[laughs] And there were students happily making this damn stuff. I've not heard of anybody who came unstuck and... [laughing]

No. And...

On the other hand, we don't know how many **were** lost that way.

[29:06]
No. And could you talk about the teaching of physics, which was the other part of your degree?

Similar. There were very good lectures, very interesting lectures, and, I was very wary, because of my cursed trouble with mathematics, and, on the... The physics teaching was only one year for me, because I had already had one year at Birkbeck and it would end at the end of the second year. So, it was rather crucial I got it right. And at the end of term examinations at Christmas 1939 I failed hopelessly in the physics test, because the bloody mathematics led me astray.

Mm.

The lead questions were on electromagnetic theory, and, one had to deal with it with a whole series of trigonometrical equations, which I just could not handle. I always got stuck on the wrong side. And... Oh, anyway, I won't go into the details but I couldn't

do it. It wasn't from lack of willing or, or, or laziness; it's just, I couldn't... And then, I thought, well, I've got to get by this or I won't get a degree, because it was a requirement. And, I was given the chance to take the exam again in, I think it was six weeks' time, after Christmas. And, so, I thought, there's no use swotting, you can't remember pages and pages of trigonometrical argument. And then, suddenly, I was reading away happily, and I remembered Oliver Heaviside, who, there was a famous scientist, famous physicist, and he had introduced the mathematical operator, the root of minus one, that, you know, sort of, baffles everybody, [laughs] and [inaud] get, used to baffle them. They're not baffled any more because the computer handles it quite happily. But it sort of, nearly gives you mental diarrhoea if you start trying to think about it. [laughs] And, anyway, using the root of minus one you can reduce the trigonometrical proof from about three pages down to about five lines.

Wow.

Now that was easy to remember, and I didn't have to worry about which side the equation was on. So with a lot of anxiety, when I sat the exam and I came to all this stuff on electromagnetic theory, I bunged down the, the proof, using Heaviside's operator. And, Manchester being Manchester, and with a Nobel Prize-winning professor, instead of being chided for my laziness in using this escape, I was praised, happily, by them, saying, 'Oh we've never had a student that used operators before.'

Mm.

They said, 'Extraordinary, a total failure at Christmas, and now you're [inaud].' [laughing] And it was, it was just... Mathematics has never bothered me, it's just the arithmetic operation that I come unstuck. The concepts of mathematics I love, in fact, I spend an awful lot of my time building models and doing mathematics, and I've got another bible up there and that's a mathematical... it's a computer program, Mathematica, it's a maths processor, and that's the manual.

Right.

I, I love it.

Mm.

But I can't pass exams in it. [laughs]

[32:33]
No. [laughs] I, I know that you also sought lectures in other subjects while you were doing your science, and, one of the kinds of teaching that you sought out was bacteriology classes at...

Oh no that was actually scheduled.

Ah. Part of your degree?

Yes. We were allowed to take an optional subject.

And you took...

And one of them was bacteriology.

And, in your book you describe your feelings about that as being entrancing.

I was.

I wonder whether you could expand on what was entrancing.

Well, bacteriology was not taught at the university, but at the Manchester Royal Infirmary, down the road, as part... And so you, you shared it with the, the teaching with medical students who were doing the same course. And, it was, it was very much pathologically oriented. In fact you might say, that was what was wrong with bacteriology as taught in those days, because, it, it caused people to imagine that bacteria were largely pathogenic nasties. There was very little that was taught about the enormous variety of natural, normal organisms that exist in the world, in fact that run the whole damn system, and, the infrastructure of the whole planet. So it was a

very biased, one-sided, humanistic, pathological side of bacteriology. But it was nevertheless fascinating. I mean, we had to do hands-on, it was immensely hands-on, we would do things like looking at sputum samples from... because tuberculosis was a major problem in those days, and, identifying the tubercle bacteria in the sputum by the acid-fast stain procedure as they call it. You put a bit of sputum and spread it out on a microscope slide and then heat it in a flame until it's dry and there's a thin film. And then you dip it in a dye called Congo red in alcohol, and the bacteria and everything is stained vivid red. And then you wash the slide with strong acid, a fairly strong sulphuric acid, and this takes all of the dye out from the, every one on the slide except the tubercle bacteria. They remain stained vivid red. So then when you dry the slide and put it under a microscope, there you can see them if they're there, these little red rods stuck round

Mm.

And, oh I mean there was all sorts of stuff. I think they did this deliberately. At one point you had to pipette up, you know, a pipette is a long glass tube and, you suck up with your mouth something in it. Typhoid bacteria, [laughs] suspensions of the...

Mm.

It was probably a harmless strain, but I think they did this deliberately, just to scare the pants off them and make sure our technique was good and we were knew what we were doing.

[35:40]
Are you able to sort of, isolate the aspect of studying bacteria that created the interest for you, in relation to, for example, organic chemistry which you found relatively less interesting, is it something about the, the movement of the bacteria, or the shape, or the structure, or their activity, what... Can you remember precisely what enchanted you about studying bacteria as opposed to a compound or a material?

I think that's a wrong way of asking the question, in a sense, if you don't mind my saying so.

Not at all, no.

It was the whole damn gestalt. I like going along to the infirmary. There's something dramatic. I mean, the, the media people know this, the hospital dramas are always in the thing. It's, a hospital is a frightening and an interesting place, so I like going along there, and feeling part of that environment. That gave me quite a bit of a, a small-scale thrill. And, the handling microscopes and looking at things. It's all, it's rather a pleasure doing that. But, I think bacteria themselves was the least part of it. It was the diseases, the, the environment, the whole, as I say, the gestalt. I didn't relate it at all to my organic chemistry, other than that I was interested in the fact that the tubercle organism has this lipid layer around it which is so impervious that it, it's resistant to the strong acid that was used to, to wash the slide. And, they are quite resistant to acid ordinarily. And it led eventually to a paper that appeared in *Nature* I had in, when I was working at Mill Hill on the mechanism of action of a certain anti-tubercular drug that had worked, that had succeeded with animals but it was never used with humans, that was developed by Kappa Cornforth. It was a kind of, peculiar kind of detergent. And, this accumulated within macrophages which were the cells that contained the tubercle, and was able to show that, that this detergent was magnified inside these macrophages and this stripped the, this outer layer of lipid away, and that's what made the tubercle vulnerable to attack by the macrophage itself.

Mm, aha.

And, it was a nice piece of work. But, it related back in my mind to that, I mean, when I got posed the problem, what do you think is, how on earth are these damn things working? And, and that's what led to it.

[38:44]
Thank you. Now I know this is a long, long time before anyone was talking about the two cultures, but, in your first year you shared with a history student, and, there must have been other kinds of students and friends around. I wonder at this time how scientists were viewed in relation to other students. So how were, how were scientists seen in relation to, history students?

I think it depends what strata of society you were in. I can put it most bluntly, when I arrived in Manchester, with great, I wouldn't say fear, it's too strong a word, but feeling horribly insecure, it was a city I had never been to, a northern city, I was interested, I hadn't much money, what on earth am I going to do for the first night before I go along to the university? And... Because I knew they would find me lodgings somewhere. And, with a lot of doubt, I approached a taxi driver at Manchester's Euston Road station I think it is, and said, 'Can you take me to a hotel that won't charge too much for the night?' And he said, 'What, what...?' I said, 'I'm a student.' He said, 'Oh leave it to me.' And he took me to a commercial hotel, which wasn't far from the university. And it was splendid. Very cheap. And a wonderful breakfast, and quite comfortable bed. And it was mostly lower, lower level whatnots, you know, commercial travellers used it. And they know where you can get good value for money.

Mm.

And, it was essentially a working class environment. And when I sort of, they all asked what I was doing, they thought I was some junior sales rep I think, and I said I was hoping to enrol as a student at the university, and they all sort of cheered me on, saying, 'Oh, yes, that's, that's the thing to do. You're young, get yourself an education and that's how you'll get on.' From the working class environment they didn't care what you did at university; as long as you went to university, and furthered yourself, it was the right to do. And, whether it was science or history or something else was neither here nor there.

Mm.

It was, sort of, using one of the escape routes, and they, they cheered you on. They could have been bitter, there were a few like that, but not many. And... So, I don't think that kind of issue came up very much, except as a middle-class issue, and I wasn't really moving in those circles at that time.

What about among students themselves? Mixing with students from other subjects.

Well, you see, because I'd been trained in the practice of chemistry so thoroughly, the practical classes, which took up three-quarters of the day if not more, I got through almost like a dose of salts, just, like that, bang.

Mm.

And, I thought, right, we've got all these things to do. I'll do 'em. And then I've got all the rest of the time free. And, then, that was then that I went along to other lectures, like, I went to quite a few in economics, and, quite a few in history, and other subjects, and got to know a lot of other students that way. That was how.

Was there a, a difference in status between subjects? I mean was...

I wasn't aware of it.

Mm.

I think, this is all post-war. You see, people don't understand that not more than about one or two per cent of the population went to university before World War II. And all of that one or two per cent were, tended to be vocational, even when they were from the working class. Like me, they were people who were going in to whatever their subject was, not just because it was a route to a better job or more secure living, but because that was their interest and their, their passion in life. And gradually it's changed, and I think the, the Blair Government's idea of fifty per cent entry to university is a sheer madness, unless you regard the university as something totally different from what it was originally. It's no longer then the seat of learning, it's a kind of, holiday camp or cultural indoctrination place for everybody. And that, I wouldn't say that's an unworthy role, but it's not what university was.

[43:05]
Mm. Thank you. Would you be able to tell me about your relationship with Mary Delahunty, which I think was...?

Sure. Yeah, no. Well, naturally being young... I soon found that Lois Dickenson, who was by then in the third year in chemistry, was, not just not interested in me, but highly embarrassed and unpleasant about my turning up at the university. I mean she regarded me very much as a stalker.

Mm.

And, I had no, no wish to be...

How, how did her feeling about that express, how did she express that feeling?

Well just, obvious. Very very positive, a negative response. I don't think she was very sexually inclined at all. And, she became I think chief chemist for Boots, you know, the people, at their plant at Nottingham. And was quite distinguished in her field later on in, in life. But as far as I know, she remained single, but I may be wrong on that one.

And Mary... and, how did you come to meet Mary?

Ah. Well, it was a peculiar thing. There was a women's college, what was the name of it? It began with an A. Anyway, it's unimportant. It was part of the university. And, they were holding a dance, and we were all invited along to it. And I thought, well I'd like to go, but I don't know how to dance. And, I tried going to, get taught by a woman that taught dancing lessons somewhere on, in the Oxford Road, opposite the university, but I couldn't afford it, after two I had to give up, it was beyond me. And, I learnt a bit but not much. And then a friend of mine who knew, said, 'Why don't you join the Ambrose Barlow Catholic Society?' I said, 'What?' And he said, 'Yes,' he said, 'I'll introduce you to a couple of friends of mine who are,' you know, sort of senior members of it. And he introduced me to a marvellous pair of chaps. There was Kevin Cave was one of them, and, somebody Johnson, who lived in, in... I can't remember his first name, who lived in Preston. And, oh they were the most wonderful pair of intellectual friends. They took me back straight away to the kind of, upmarket Leakey set-up. Their conversation was entirely politics, but a different sort of politics entirely but quite interesting. And the Ambrose Barlow Catholic

Society did all sorts of intriguing things. They had moral theology debates, and, I joined in with this, and became a member of the society, even though I wasn't a Catholic. And one of their kind of, perks, was that, at the, I think it was the Church of the Holy Name just across from the university, they had dancing classes in, in the basement, [laughs] I've no doubt to encourage good Catholic marriages, getting the youngsters together. So, I went along there, and was happily accepted by the Catholic girls. They were mostly Irish, either from Ireland or, much more likely, for immigrants. The north-west was largely composed of Irish immigrants back in those days. And, it was there that I met Mary Delahunty, and, I fell for her; whether she fell for me, I'm not quite sure, but anyway, we certainly had a good relationship, and, it lasted quite a while.

[46:57]
You mentioned at one point that you had a particular attraction for Catholic girls, and you...

Sure.

You had some suspicions about where this came from. Can you elaborate on that?

[laughs] Oh, well, one... I think it's part of the urge to exogamy, that all animals have, you don't, you want to mix your genes up a bit. So, I'd been brought up by, my mother was... I, I don't want their... She eventually became a Quaker, but she... and she was interested that way. But, otherwise, she regarded Catholics as the work of the Devil. Almost, a very common working-class attitude generally. I mean, Guy Fawkes Day had much more significance than most people realise.

Mm.

And, it was certainly one of the prominent feasts of my childhood, and all around. And, so naturally, being brought up in a nonconformist atmosphere, and regarding Catholics as absolutely beyond the pale. And having one strange experience, I think I've mentioned it in the religious part of that book of my autobio, that, the way, when I was a young, quite young, must have been five or six, and, staying with a cousin of

mine, a relative of my father's at Hagbourne in Berkshire, going, suddenly saying, 'Oh I'd like to go to church,' and going... and my cousin Lily saying, 'Oh well, off you go then,' and I went across the fields to, to a Church of England service. And I think it was the sound of the bells that really appealed to me. Anyway, I got there, and went through the service, and everybody was so nice and so welcoming, wondering where I'd come from, things like this. 'A little boy like you coming all the way...' [laughs] It was wonderful. And, anyway, that was end of that. So... But then in Brixton I tried to repeat the thing by going to a Byzantine Catholic church at Tulse Hill, and, I had hardly got in the church and sat in a pew before up comes the verger, seizes me by the scruff of the neck, says, 'Out, you, you don't belong here!' And, that left me with a very negative feeling about Catholics...

Mm.

...at a rather young age. And, my family and whatnot did nothing to dispel that feeling. So, when I got to university and I found, I got this offer to join this society and found they were so different, that, suddenly the exogamy side of it, probably kicked in. And these girls were much more attractive than the non-Catholics. [laughs]

In terms of appearance, as well as...?

Gestalt again I think. I don't think you can pin it down to any given degree. I mean, attractiveness of a woman to me is much more concerned with her voice, and what she talks about, than her appearance. I've often thought that for men like me, there's a kind of threshold. You would accept a girl that, in those days, when I was young remember, if, if a girl wore spectacles, it was that, the whole thing was it. There's an Ogden rhyme, Nash, about, men seldom make passes at girls that wear glasses. [laughs] I wouldn't, that wouldn't worry me one bit. I think I've probably drawn the line, this is an incipient moustache. But, generally, it wasn't the appearance that mattered, it was the voice. And, there was one particular woman, who was in the Catholic Society, a girl, I've forgotten her name, who was unattractive, dumpy, but her voice and personality were so good that she really was an attractive person. I had

already met Mary by the time I noticed her, but, so it didn't, didn't make any difference, but I could easily have gone along with her instead.

And, finally before we move on from university, could you describe...

But before you do, I think this is this business you were asking about falling in love. It's such a difficult thing to understand or whatnot, and it's got, for me at least, an awful lot to do with personality, voice and that sort of thing, and, communication, than with, with external appearance.

[51:39]
And in the case of Mary then, what was it about her?

She was quite good-looking, but, but... Oh, she was really first rate, I mean, and she was quite an intellectual. She read much more extensively than I did, and introduced me to all sorts of authors that I had not read before, and, our conversation was quite advanced. And, she not only was aware of all things like that, but had a real mind of her own, and could debate, talk about them and argue about them. Oh she was somebody I, I liked very much, yes.

What was her view of... She was, she was not a science student?

Oh no, not at all. She was the secretary to the architecture department.

Ah. Mm.

[52:34]
And... She was, she had never been a student. But she came, came from a wonderful Irish family, that I integrated with. Her mother, Helen Delahunty, had raised, I think it was six kids, in Moss Side, which is of course the slummy part of Manchester, on her own, by playing bridge. [laughter] She, she even was a bridge, wrote articles on bridge for one of the daily newspapers, I've forgotten which one.

Mm.

And that was her... and she supported entirely on, on bridge playing, she said, mainly the winnings.

And, you said that that family 'plucked away the prickles and thorns of a childhood in the wild'.

That's right.

What did you mean by that?

Well, socially I was in... absolutely in... hopeless. Nerdish to the extreme. An anorak of the first order. [laughs] I was a member of the mountaineering club, more than, more than just in the term anorak. I did tend to wear that sort of thing all the time. And, what the hell Mary saw in me, I cannot think. But, that family completely took me to their heart and, made me more, I wouldn't say I'm normal but, much more so than I was then.

[53:57]
What changes did they make to you, do you remember?

Socially, I became far more acceptable. Far more thoughtful and considerate. My mother had the most dreadful hang-ups because of her, I mean, very tough existence. I don't blame her. But, for example, one of the awful things that I was brought up with as a child was, never accept gifts because always they will want something in return. And you can never thank people, because that might be taken as, you know, sort of, thinking it's something back, which would then make you obligated to... It was a dreadful indoctrination, absolutely. And I think I owe it a lot to my grandmother that, because I wasn't bonded with my mother, I never took it all that seriously. But it had its effect. And the Delahuntys were so different. I mean they, they taught me how to accept gifts graciously, and, which is very important in ordinary life, and how to give graciously too. And... Oh they were just wonderful people.

[55:05]
In terms of their sort of influence on you in terms of opening up literature and art?

Oh yes. Well, the... I mean, give you an example. The... Mary's uncle was drama critic on the *Manchester*... on the *Guardian*. It was the *Manchester Guardian* then of course. And, he would get us free seats in the front row of the Opera House. It was terrific. So, my sort of whole cultural education opened out just like that, with that family. I learnt more I should think from them than I did from the rest of my university experience put together. Because I didn't learn a lot of science at the university.

Mm.

More the kind of sciences I wanted to do than the, rather than what was being taught; more about the sort of, whole picture of science.

[56:03]
Was there a link then between what you've called your sort of, nerdishness or...

Mm.

...or lack of sort of social confidence or ease...

Yes.

Was there a link between this in any way with science?

Probably. We, one usually associates that, doesn't one, with people who are tied in, whether they be trainspotters, who... And trainspotters are not [laughs] the kind of people... I can well understand trainspotters. After all I went to watch the Flying Scotsman at, at Hitchin station. So, there, I mean that's the classic sort of nerd. They're people who are intense about mechanical things and, non-human things. And they do tend to lack an understanding of humanity and their relationships and so on.

And, you're not a rounded person I think unless you've got a fair bit of both in you. And, I, I owe an immense debt to those Delahuntys for that.

[57:10]
The reason I ask was, was that the, the social education seemed to run alongside an education in literary culture.

Yes.

Which would, which would seem to be, which might contrast I thought with science as an intellectual activity and the, the lack of sort of social ease. I don't know whether... Did the Delahunty family comment on you, not only as a, as a human, but as a scientist, did they...?

Oh not, not really. But they always wanted to know about things. I was a source of information for them, about, all sorts of aspects of life. I mean, they were, they were not in the least nationalistic Irish. In fact the Delahunty children used to make a great thing of singing *God Save the Queen* in the presence of the, or, it was the King in those days, the presence of the more nationalistic relatives they had, just to show them, wind them up.

Mm.

[58:13]
So... But, they were very interested in the course of the war that was going on then, and things like that. I remember having a long conversation with Delahunty after the Germans invaded Russia, and she wanted to know, what did I think it meant for the course of the war and things? And I said, 'Well one thing,' I said, this was pure speculation, I said, 'I think we can stop worrying about being bombed.'

Mm.

Because, I feel the Germans are going to need all of their air force to deal with the Russian war, which is a big one, on a big scale. And they won't have time to be chasing us. At least not for the immediate future.

Yes.

[58:55]
And that of course did turn out to be true, and... I think it was things like that that helped establish the relationship. They... Because I had grown up in such a varied political atmosphere with the Leakeys and so on, I, I was more rounded than most of the people that they will otherwise have encountered.

Mm.

And also gave a southern cultural kind of background to things. Because one forgets, the northern and southern cultures were incredibly separated, it was almost like an apartheid.

[59:26]
Mm. Thank you. As a way of exploring war and your relationship with Mary, I wonder whether you could describe one of the nights spent in the flat in Manchester while bombings were taking place outside.

That's right. Well, there always comes to a point when you're a virgin in a relationship when you go and sleep with your intended. And, we'd kissed and cuddled and things like that, but, not proceeded very far. And I imagine Mary, who probably, had a relationship beforehand and was not a virgin, was probably getting pretty fed up with me. But then, an air raid started one night, and sirens went and, it went on for quite a while. And, the time had passed for me to go home, and so, [laughs] we decided to spend the night together, and that was, that was it, the beginning of a tighter side to the relationship.

And the sights and sounds of war, from the flat?

Well, I mean it's the usual thing. You get worried, you... Bombing is never quite as frightening as people make out. Because, you get a very quick idea where the bombs are falling, and you only begin to worry when you hear a bomb whistling down, and then another one, which is a bit nearer, [laughs] get even nearer, you think, oh my God! is the next one going to get us? And of course it didn't. They always went somewhere else. But, apart from that, mostly it, it was somewhere else.

Thank you.

For example, I came from Manchester on a, in what was called a lorry in those days, it would be a truck nowadays I suppose, I hitched a ride down to my home, on the night of September the, when was it, when there was a huge bombing of London, the first one. And, I remember when the, the, the lorry was at Dunstable on the, fairly high up on the downs on the road there, seeing two sunsets. We couldn't make out what was going on.

Gosh.

There was the sunset in the south and in the west.

Mm.

And it never occurred to us that it was London on fire. Not until we got nearer. [pause] But then, as we reached London, and we had to go all the way across London from the north to Mitcham, where the lorry depot was, in the south, and, there were incidents dotted here and there, but the intensity was very very low. It was probably different in the East End near the docks where the centre of the attack was, but, for the most part there was very very little. There were bombs, and unexploded bombs all around all over the place, but it wasn't anywhere near as terrifying as I had expected it to be, seeing that great glow in the sky from the north.

[01:02:22]
Mm. Thank you. Now I'm going to move through the medical science reasonably quickly, partly because there are extant recordings in that area...

Yes.

...including the Common Cold Research Unit. But there are key things that I'd like you to talk about if possible. From 1941 you worked at the National Institute of Medical Research?

For.

19...

For Medical Research.

For Medical Research. Thank you. Holly Hill, Hampstead?

That's right.

And at one point you mention that, you were able to have lunch and coffee with your senior scientists in the building at various points, and the conversation sometimes turned to schemes for chemical warfare discussed.

Sure.

You mention the use for example of Stilboestrol powder, as an idea.

That's right.

I wonder whether you could, in as much detail as you can remember, including who you were talking with and what about, recall those conversations.

Perhaps first I should introduce it by saying that the set-up at the National Institute for Medical Research was a classic example of the best of British, although, they would have said in those days, English; the term 'British' only came much later. English research. The, the director of the institute was the then President of the Royal

Society, Sir Henry Dale, who was a, a formidable kind of, Churchillian character, quite tough, and I remember being interviewed by him when I first went, took the job on. If you were accepted as a member of the scientific staff of that institute, it was almost like the Quaker Church, you were a member and you had rights, and your ultimate boss was the director, quite, in real terms.

Mm.

It had a kind of freedom for individual action. And you were treated then as one of the elite, immediately. Once you were accepted, you were treated as one of the elite. There was no long hierarchical passage upwards.

Mm.

There would be in terms of pay and, whatever, and, the equivalent of Civil Service grades, because it was a government department, but, it, it was very different from almost anything else. And it was a scientific atmosphere which I found extraordinarily productive. And the shame is, we had so few places of that type then. I think we have almost none at all now.

Mm.

[01:05:18]
And in, this was particularly visible in what was called the coffee room. This was a room in one of the turrets on the, which would it be? I think it's the southern end of the building. And, we used to gather there after lunch to have coffee, and discuss. And, everyone that was on the scientific staff who felt inclined was there. It wasn't always everybody, but there was always a pick of really good scientists, a large proportion of whom became Nobel Prize winners or people of very great eminence subsequently. And, they would discuss problems, tell anecdotes, and, and raise questions, and the one you've just mentioned about, should we respond to chemical warfare if the Germans try to use it by being a bit cleverer, and dropping something like Stilboestrol that had been recently invented, the female sex hormone, onto great concentrations of German troops and take... And if they started developing breasts

and whatnot, and, their willies shrivelled, [laughs] it would lead to a rather loss of the warlike spirit. [laughs]

Mm.

Anyway, I mean it, it was raised. Now I might add, his was no mere joke, because the coffee we had in that coffee room came from bulls.

Mm.

So, it, it was already, they were well aware of the practicalities of this scheme. Unfortunate animals that are milked instead of performing their usual function. But, anyway, it was typical of the things. And the general conclusion, if I can remember back for then, was, on the whole this is not something you would do, certainly not, not, you certainly wouldn't start it.

[01:07:17]
Mm, yes. Could I ask you to describe a particular form of field work which I know you're engaged with, and that is, your use in the field of the slit device for collecting and counting bacteria in the air. And first of all, could I ask you to describe the, the slit device as an object, and then, could I ask you to describe a typical night's work using it, including meetings with the nurse from Guy's Hospital.

That's right.

So, the instrument and then the field work.

OK. When I first joined the team of scientists at the National Institute, that included the, my immediate boss if you can call him that, Robert Bourdillon, a, a delightful gentleman if ever there was one. His father had been a fairly well-known Victorian poet, and, he was distinguished, he was a fighter pilot in World War I, and had, was decorated for bravery in, in doing that. And he was... but he was also, after the war... He had studied physics before the war, and got involved with bomb sites during the First World War, and then, after the war he went into medicine, because he thought a

knowledge of science would improve medicine. I think his experiences with casualties in World War I led him to go... He was very much a driven, very honourable man, you couldn't have asked for better. And my colleague, Owen Lidwell, who I think is still alive, and lives in, somewhere, maybe in Falmouth I believe, somewhere in the south-west, was an Oxford PhD, DPhil I should say, yes, and had been at Balliol, and was what you would call ordinarily, the cream of, and sort of classical for the Medical Research Council. I only got in by the weirdest and strangest of accidents, into this elite establishment. Partly it was wartime, because, difficult to get hold of young men of the right type, and secondly, because Todd, my professor at Manchester, was the son-in-law of Sir Henry Dale. And, the director must have said, 'Oh we need a young scientist for this rather important work on infection transfer, and, has got to be a very hands-on type, we don't want an academic kind.' And Todd, [laughs] hardly had to think, and thought, absolutely ideal for Lovelock, and, recommended me. That's how I got it.

Mm.

I had a bottom second degree from Manchester, which is hardly [laughs] recommendation.

Yes.

And I was competing with DPhil's from Oxford, in a sense. So...

Mm. You suspect it was...

Just shows what nepotism will do. [laughs]

Yes, but you, you suspect it was something to do with the leaning for practical science though?

I think so. Because, in wartime, because, when I was interviewed by Sir Henry Dale, he said, 'You realise that this is very different work. It's no longer science. We're at war and we have problems to solve, preferably yesterday, important ones. No

academic messing around.' He said, 'But you wait, after the war my boy, we'll get back to real science and then things will be different. But for now, it's... can you do this, that sort of thing, chap?' And he said, 'I see you're a conscientious objector. What's going to happen? This is a government department, we may be asked to investigate almost anything. What are you going to do, if something comes up that's contrary to your conscience?' Now, I remember that so well. And, my reply was, and it must have been after a slight hesitation, because I had to think that one out, was that, 'I think I would treat it on, the problem on its merits when we come to it. I can't answer it hypothetically now.' And he seemed to accept that as, as the only sensible thing anybody could really say to that, that question.

Mm.

So I got in.

[01:11:53]
And, the, the slit sampler as a physical object, could you describe...?

Yes. My colleagues, Owen Lidwell and, and Robbie Bourdillon, had invented a remarkable bacteria sampling device, which I don't think has been bettered ever since. In, in mechanical terms as an invention, it was horribly cumbersome, but that was, that wasn't the point. The essence of the idea was very simple. There was a slit about one inch long, and, I don't know how wide it would be, about a tenth of an inch wide, through which air was being drawn, quite fast, at one cubic foot per minute. This is a fairly fast rate of airflow. And, it impinged onto the surface of a culture plate of agar gel that was underneath it. And that plate was rotated mechanically so that it went round, so that like a CD, you had a trace in time of the bacteria that were in the air, and that impaction collected well over ninety per cent of all the airborne bacteria, dumped them on the agar, where they grew and formed colonies, so that you could count them after incubation. So it was, it was a really wonderful way of sampling the air for its bacterial content. Of course it didn't do viruses.

No.

[laughs] Which was the important thing. But at least it did for bacteria. And there was, it was felt that... And we could use culture plates, the agar of which was poisoned with a small amount of potassium tellurite for example. And on those, the only salivarius organism that, streptococcus viridans that lives in your mouth will grow; it kills practically all other organisms. So that gave you a fair idea, the number of those in the air, how many, much respiratory stuff was circulating in the air and that you were sampling. There were all sorts of dodges like that. It was a fairly thorough and professional investigation that they were up to.
[01:14:11]
And, we used this slit sampler in all sorts of environments. An important one that I was involved in in wartime was in operating theatres. I sat with one during a brain surgery, for the whole eight hours of it, in a hospital in Birmingham.

Could you describe that please, and...?

Which?

The, the surgery, the brain surgery, with the... I mean, could you describe where you were in the room, what you were wearing, and how you actually operated the machine over the time of the brain surgery?

I can't remember my exact placing, but it was at some distance from the operating table. And it wasn't all that large a room. I would think it would be about twice as big as this room we're in at the moment.

We'd better say how big that is for the recording. So... I'm not actually very good at...

Sheer guesswork...

Yes, that's fine.

Say, not a large operating theatre. I mean it wasn't one of these cavernous places with... And, it, it had fairly advanced air-conditioning. That was the whole point of

my being there. And, the whole thing was overseen by a quite famous doctor called Dr Leonard Colebrook, who became a personal friend after World War II. He was the one that introduced the drug, I think it was called Prontosil then, it was the first form of sulphonamide for... It was the first antibiotic ever used, that's right.

Ah.

And he became quite famous for that. And, anyway, he and Bourdillon had worked out the air-conditioning design for this operating theatre, I think, I'm having to go on memory here. So that it, it prob... one of their favourite dodges was to use what was called piston ventilation; that is, the air came from above, through a sort of gauze screen so that it came down in a steady flow like this. And so any bacteria stirred up by people in the room or at the operating site was swept downwards and out, rather than ventilation where the air was being mixed up continuously and drawn out. And it was a good idea and it worked.
[01:16:25]
Well my job was to just check the general bacterial level in the room with a slit sampler. And, I remember going in there with Colebrook in the morning and we got gowned up, and, he was just acting as an observer and wasn't there all the time, and the surgeon came in and the patient was wheeled in later. And the thing that struck me then and always has done about surgery is how leisurely it is. [laughs] It may be frightening for the patient, and the surgeon, but to an out, an onlooker, the whole thing seems very calm and slow. And they open up the brain and they, they take away the sort of circular bit of bone and, start going in. I couldn't, I was too far to actually see them doing it, but I knew what they were up to from what, what I could... what I could see, and what they were talking about. And... And the patient was conscious during the operation. Had to be.

And, talking?

It was all done by local anaesthetic. Oh yes, because they would ask questions. And...

Was the patient aware of you there?

I've no idea.

[01:17:33]
And, I'm trying to picture the, I can't picture the object at the moment. I imagine you sitting in a chair. How big is the slit sampler that you've got? Is it a great big column in front of you, which is what I'm imagining at the moment? Is it...?

It's about the size of a computer, that sort of dimensions.

So, not even a metre high then perhaps?

No.

And, and it's got the slit inside. And, the rotation of the plate, did you have to manually rotate?

No no no. It was mechanical, electrical. No, there was an electrical air pump that was drawing the air through the thing, and there was... What we used mostly for that sort of thing were, were clock motors. You know, you, in those days you could buy them, but nowadays, it's long since gone. It was a neat little cylindrical electric motor that rotated once in an hour or once in, you can... there's a dial on the side, you could set it. They're all at fixed, things. And, this one would rotate once in twenty minutes for the slit sampler, would be a typical thing. And when the twenty minutes were up, you would take the exposed plate out and cover it with a lid, a glass lid, and put it in a can for its subsequent incubation and put another one in at the same time, start it again. So it's a more or less continuous recording going on.

Mm.

Like you're doing now.

[01:18:54]

Yes. So you were there to sort of, to replace the plate. Was there any sort of, adjusting or calibrating or work that you needed to do with the instrument at the time of recording?

Yes, sure. You had to watch that the air pressure stayed constant. I mean, if some bit of fluff had come in and blocked the slit, you would have seen it because the air pressure inside the chamber was negative pressure, sort of, would then fluctuate from the set level that you knew would draw one cubic foot of air a minute.

And how was that, did that have a dial showing the key, the...?

No, it was much more straight, basic than that. It was a column of fluorescent water, water made fluorescent by adding a trace of fluorescein to it, that just sat in the glass tube against a scale. And as long as the meniscus of the water was level at the, whatever mark on the scale you knew was for one cubic foot a minute, then you were all right.

And, did you notice through using that that levels of bacteria in the air changed at certain times throughout the operation?

Sure. Yes, you kept an eye... I mean it wasn't just a matter of sitting there as a kind of, recorder operator. You had to keep notes on all the various steps, and the timing of those steps in it, so that you could compare the events on the plates that were subsequently collected with what had happened.

So in other words, skull is, parts of skull removed...

Yes that's right.

You'd note the time of that.

Yes. That was important, because, disturbing the hair can cause a cloud of bacteria to go up.

[01:20:30]

Mm. Thank you. And, other sites where you used the slit sampler, operating theatre, where else did you use it in field work?

Well, we did quite a... But Lidwell did quite a bit as well as me. I think he went along to the, where they were doing the, McIndoe, in, where was it, in Sussex somewhere down there where they were doing, treating those poor unfortunate airmen that got badly burnt. Some of the pioneering treatment of burns, there was, called a burns unit down there. And it was most important to keep potentially pathogenic organisms at bay.

[pause]

Right, yes. So, he dealt with that. I remember going to a hospital down in east London, which was in the... that was, I think during the V-1 period, a pretty hairy part of London to be in then, and that was not in an operating theatre, that was in, there was an epidemic of haemolytic streptococci, which was a nasty sepsis organism that... And very easy to identify, because, when they grew on the culture plate, a blood agar plate, you got little punched-out circles of haemolysed blood, so you could see instantly which were the haemolytic streptococci from the others. And we were, they spent quite a bit of time analysing how that epidemic was occurring. And we solved the problem as far as I remember. And, that was, there was one single patient who was a, what's called a nasal carrier. His nose was heavily infected with haemolytic streptococci, and he contaminated his bedding, himself and everything. And every time the nurses made the beds, great clouds of the things soared into the air, and settled on all the other patients around. And if they, any of them had wounds at all, then, there was grave danger of, of sepsis and so on.

So did you discover that by moving the slit sampler to various places, recording various places?

Not so much... Since the air of the room always is mixed up, in an average room, all you have to do is to set it somewhere in, preferably not near the edge, or where the air's coming in or it's going out, and, sample the air, and just notice, allow for the

time, get a record of the time when various events happened, and you would know. We also used smoke tracers quite a bit. We used a chemical called titanium tetrachloride, which when you exposed it to air, it's a liquid, it produces dense white smoke, and you can see which way the air is moving inside the room.

[01:23:25]
What was the, the patients' and the nurses' and doctors' perhaps view of you, presumably sitting in a ward, making notes with a machine running near to you? How, how were you viewed?

Oh pretty equably. [pause] But, the important thing with all hospitals in those days, [laughs] and I find it so very funny, there weren't any administrators at all to speak of. Or if they are, they were minor clerks somewhere down in the basement. There were no managers. And the important person to see first of all was the matron. Everything ran according to the matron. They had, talk about women's power, they don't know what they gave up when they gave up that one. [laughs]

Mm.

And, the consultants, everybody, was frightened of the matron. And boy, they were wonderful women, they really were. And, as long as you got on the matron's side, all was well. The whole thing ran like, there was no nonsense, no fuss, no nothing, and the nurses supported you and, the system supported you.

To what extent did you speak to patients as part of this field work?

Quite a lot. It depended on the patient. I remember sitting, having my, had my sampling machine next to a bed where there was an MP, and, he was from your part of the world I think, somewhere up in that, that direction. And, we talked quite a bit. And we got utterly disgusted. This was the Royal Free Hospital incidentally, the women's hospital. And this was the men's ward. They had to have men there because otherwise the girl trainees wouldn't know what a man was like. [laughing]

Mm.

And, anyway, there were two young nurses came up. I, I hope that... Not nurses, trainee doctors came up. I hope they were in the, not in the third year, they were, they were first- or second-year, something like that. And one said to the other, 'Oh I see this patient is prescribed codeine. What's that for? What is it?' And the other one said, 'Oh it's something like aspirin isn't it?' And, I was shocked, absolutely, to the core.

Mm.

And not really justifiably, because really, all those young doctors needed to know what codeine did.

Mm.

What it was. And, the answer was something like, is not too far off the truth. I mean, instantly, the chemical formula for codeine [laughs] sprang to my mind and I thought, how ignorant, don't know what it is.

[01:25:56]
Yes. Thank you. You also mention... Oh, perhaps we ought to then, perhaps, could you tell us about the relationship with the nurse from Guy's Hospital? Presumably that was...

Ah, that was in the tube tunnels. When we first, when I first started work at the National Institute, the main problem exercising their minds, the Blitz was not long over, and, I was enrolled there in June 19... when would it be? '41 was it? Yes, presumably. The blitz was not long over, and, they were quite worried about epidemics amongst the people in the Underground shelters in London. And conditions in some of those shelters was quite literally mephitic.

Mm. Mm.

And, there had been the epidemic of influenza in World War I that had killed more people than the war did. And this was the nightmare in the minds of the MRC, that something like that would start in London under the close quarters of the Tube shelter system. So, one of our frontline activities so to speak was to go down in these Tube tunnels and sample the air, to get some idea of what was going on. It was quite a programme. And I was much involved with the Tube shelter programme, it was the first tasks that I did. And it was pretty hard work. I mean I can remember being, working twenty-four hours a day for nearly three days running on that. There were so few of us you see to do it. And... But when you're in your twenties, it, it's nothing, you can cope with that sort of thing and, laugh it off.

[01:27:39]
And what did the work involve, what did the field work involve with the sampler, in the Underground?

Not a lot of work actually. But, going down into the Tube tunnel... And, it wasn't just a Tube station, like the pictures you'll see in the films and things. And we're talking about old, disused Tube tunnels near London Bridge that were, oh could be anything up to half a mile or more long, that had just been dug and then not, not actually used, but still existing. And... Or, or had represented failed railway, Tube, railway lines. I think there was the old Twopenny Tube was one of them, was called, that was one early one that didn't make enough money so it was just abandoned, and, it may be still there for all I know.

Mm.

And... Anyway, these were filled with people, up to the gunnels. There were just these sort of, beds, three high, it was just sheet, wire mesh on a frame, quickly bolted together and produced under wartime conditions, and some sort of flat mattress rested on this mesh, wire mesh frame. And, there were people there by the dozens. And, we soon discovered that an awful lot of them were not down there really to shelter; they were people from that part of London who had let their houses, [laughs] and they were using, sleeping down there and they were getting the money from the, from the

letting. And they were warm and comfortable enough down there and they were surrounded by their mates. What more could they want?

Mm.

It was a pretty, pretty rough old atmosphere. I, I didn't see it myself, but I was told that during the war itself when the density in the tunnel, of course they were very safe, they were, at least it was thought to be, against bombing, was so great that the oxygen in the air fell below thirteen per cent.

Gosh.

It was that, that overpopulated. And what was interesting about it, how they knew that, was that, a bitter complaint from the people down there was, they couldn't smoke. Because, they could light the, strike the match, and the pyrotechnic would burn, but the wood wouldn't, because there wasn't enough oxygen in the air to support combustion.

Gosh.

It'll support life, but not... thirteen per cent, but not combustion.

[01:30:10]
Mm. And, where did you, how did you use the slit sampler in the Underground?

Well, there was always somewhere you could fit it up. And, that was quite a problem, because, what the nurses did, of course they had shelters down there for dealing with immediate accidents and things. Anything from pregnancies, there were quite a lot of those down there.

Mm.

Babies born.

Mm.

And, and, they recruited, because they were pretty fly people, those nurses working under those conditions. And there was, also, what was so important in those days, in the working-class people, an immense respect for uniformed nurses, and the same immense respect for nuns, anybody like that. A nun or a nurse could walk in, at any time of day or night in the roughest area of London with no fear of attack whatever. It just wasn't done. This is something that's all changed since the Sixties, and I don't know why.

Yes. What about respect for scientists carrying slit samplers? I mean, how were you viewed by the population and...?

It was... I had no problems whatsoever. I don't find it difficult to talk to, to people. My origins were in the same class, so I, I've got no hang-ups. I'm not a toff, sort of, lording it over them. I'm one of them in a sense, and part of the whole thing, just doing a job. And, they wouldn't take all that notice of a plumber, so why should they take all that notice of me?

Mm.

That, it was that sort of atmosphere I think that made it easier. Although I did note that my colleague Owen Lidwell, who came from a much higher social strata than I did, his father was a bank manager, you know, middle class kind of thing, and, he spoke with a very strong Oxford accent, the kind of artificial accent. But they seemed to quite accept him as part of the...

[01:32:18]
Mm. And were you making notes on the sort of things happening in the Tube?

Oh sure. Oh sure, you bet.

What sort of things would you be recording there in relation to air?

Any event that happened that stirred up a lot of anything. All you had to watch for were events such as, somebody making a bed, I mean they're not necessarily violent events, that you knew would stir up a lot of dust and stuff, and, see if it was confirmed on the samples.

Yes.

But they also tried experiments disinfecting the air, which I thought were a bit of a joke.

Mm.

But that was very much part of the scene, and very much my type of work. Because back at the Institute I used to test whole series of aerial disinfectants by spraying them or evaporating them into the air of a test chamber, into which live bacteria was sprayed and then the slit sampler checked whether the, the agent had worked or not.

Mm. Mm.

[01:33:23]
That's where I made my first quite significant invention. [pause]

Go on.

Mm? Oh. Well, the theory was, that they all believed, was that the disinfectants worked, by the fine spray of particles in the air bumping against the bacteria, the aerosol, and that's what killed them. And, I began to think about this, and it didn't make sense to me. So, I went back to the physics of it, and looked up the mathematics developed by somebody called von Smoluchowski I think it was, about the probability of collision between particles in the air of different sizes, under Brownian motion in the air and so on. And, it worked out that the average density of bacteria and disinfectant particles they were using, the half-life of a bacterium would be measured in days.

Mm.

And we knew from the chamber that they were being killed in seconds, so something was definitely right up the creek.

Mm.

And then the very, the obvious thing occurred to me, well it must be vapour that's doing it, not... because vapour molecules could diffuse onto the bacterium quite quickly and do the job. And, so how do you prove it? And then I thought hard. Well I sprayed into the chamber an absolutely lethal disinfectant substance that was, had no vapour pressure at all, and that was the cationic detergent CTAB that was used a lot in, in those days. And that killed nothing at all.
[01:34:55]
And then I vaporised lactic acid, which is an absolutely harmless acid, it's part of your body thing. But I knew that the pure acid, the, the hydrogen ion concentration, if the vapour condensed in the bacteria would kill all the bacteria, and boy did it kill 'em, they went, boink! like that.

Mm.

And, that led to a paper in *Nature* almost immediately, I think that was my first publication.

[01:35:22]
The final thing I'd like to ask you about for this period is the, you mention that you worked on bomb, a set of bombed-out streets in Canning Town?

That's right.

I'm not sure whether it was with the slit sampler, but you can perhaps tell me.

Oh no, that wasn't. As the war developed, the bacterial problem began to be put on the back burner, because it was fairly obvious that, a) there wasn't going to be any

more heavy bombing, at least not until the V-1s appeared, of London, and, so the, the shelter problem went into abeyance; and, also, it was a kind of dotting i's and crossing t's, we were doing what we, we all knew about. And there were urgent other wartime problems. And one of, one that we were recruited in, into doing something about, was burns, how do you save soldiers and sailors from damaging burns? And, I mean it's not commonly known for example, if, if you're on a ship, a merchant or navy ship, and there's a attack, and a shell bursts or bomb bursts, an awful lot of the damages to people is done by burns, not by being hit or by the explosion itself. And, what could we do about, about that? And, I think, it was the work of my colleagues, I'm not absolutely sure about this, it needs checking, that led to the flash helmets. Do you remember the...?

Mm.

They were white...

Yes. Yes.

[01:37:05]
What I was involved with quite a bit was the more basic stuff. What was it you needed to protect bare skin against heat radiation damage? Because it was the radiation damage. And I rapidly became involved in some quite fearsome type of experiments. We went to various army places where they were using flame-throwers, and, I got first-hand experience of what a, a fearsome weapon that is, because, the radiant heat from a large flame-flower, even if you're many yards away, fifty or, fifty yards I think away, is sufficient to burn you if you're, on your, your exposed skin. You don't need the flame to touch you. The heat from the big wall of flame, radiant heat, is, is going to do the job. So what you do to protect people against any, any level of burn damage. And, what, what we found was quite extraordinary, that one of the best protections of all is just a blanket.

Mm.

And soldiers nearly always have a blanket around somewhere. And, that made me think. Because, it's evolutional history. What does the rabbit need, or any animal need, in a forest, against a forest fire? It needs a skin that's not going to get burnt.

Mm.

So, one of the prime needs of fur is the fact that, wool has evolved and fur on an animal to be uninflammable, not only uninflammable, but, even better than that, you see what happens, if a flame or great heat impinges on a blanket, it boils up, and turns into a layer of carbonised matter, which is uninflammable, and has almost zero heat conductance. So underneath you're protected.

Did that occur to you at the time, the link with evolutionary natural materials?

Not until I'd got on to Gaia, many many years later.

Yes. And how were the streets used in order to do this work on protection from burns, this...?

They weren't. This was, we were involved with the use of flame-throwers in street fighting, in the latter part of the war, and, Canning Town, an area of Canning Town that had been so badly bombed that it had been evacuated of people, either voluntary or the Government made them move, I don't know, was used for street fighting experimental stuff with soldiers. I mean there were big flame-throwers would go down the street and, they could shoot into houses and things like that, and, we had gear set up to measure the heat, radiation and stuff. That was another invention I made with a bit of paper that, to tell you whether you'd get a first, second or third degree burn.

So was it partly about... The blanket was about defending soldiers from the effects of heat. Were you also involved in advising on ways of, I don't know, achieving maximum damage with a flame-thrower aimed at another?

No. No.

No.

No, no.

It was about...

Because the, we were the MRC.

Mm.

And our prime objective was what, what medical services do generally, they're not out to kill people, they're out to...

No, to care for...

Care. Although, it would have been very... I must admit, with a Quaker background it would have been very difficult for me to have been involved on the other side of the research. I don't think I would have wanted to do it.

[End of Track 4]

[Track 5]

Could you, at this point, explain and describe your work which was done while you were at the Common Cold Research Unit from 1946 to '51?

Mhm.

And it involved a monitor mounted on a bull I believe. Could you...

Yes, it... [laughs]

Could you go on to...?

Well, a four-legged ungulous animal... [laughs] Yes. You must wonder why I was doing this at a common cold research unit, and what has it got to do with a common cold? The answer is quite simply, nothing whatever. It was a colleague of mine who had worked at the old institute at Hampstead... at Hampstead, yes, Frank Raymond, had left the MRC and gone to work for the, I think it was the Agricultural Research Council as it was called in those days. I think it's something quite different now, but that's neither here nor there. And he was working at the Grassland Research Unit at Stratford-on-Avon. And, what they were doing was, they wanted to exactly follow the course of various breeds of cattle's activities, and co-relate it with the amount of meat they put on for, for eating a certain amount of grass, aiming for cattle breeders to produce the most efficient sort of meat producers from cattle grazing. And this spiked my nerdish instincts that, oh well, this is an excuse to build a, a radio transmitter sitting on top of a bull, or a bullock or whatever, that will tell you all the movements it makes and send them back to a recording station and it can come out on charts of paper or whatever they want. And, he got a group of us and said, 'Do you think you could do that?' And I said, 'Well I'll have a try anyway.' And I went back and designed a fairly simple radio transmitter. There were a number of little problems then. In those days of course the only way you could make radio signals was with what were called valves in Britain, or electron tubes in America, they're evacuated little glass things that contain a hot filament and, which emits electrons and electrodes to collect them, and the way to control them. And, the problem with those things is,

they do use a lot of energy, to use... I mean it would be nothing nowadays, you could just mount a mobile phone and a few connections on the back of the animal.

Mm.

But in those times it was really hard work. Anyway, I had managed to find an electron tube called, and I think it was an ECC31 or something like that, I've still got one or two of them around, that would produce a watt or two of radio frequency energy at pretty high frequencies, I think it was about 150 megahertz, without, you know, using an awful lot of power, it would run on reasonable size batteries for quite a reasonable time, and mounted the whole thing up. And then there were leads and connections so that when the thing was chewing the cud it made a certain sort of signal, and when it was doing this or that it made another signal, and, I left that all to them. And, it worked quite fine, and, we referred to it as the first working oximeter. [laughs]

[03:37]
Mm. Yes. [laughs] How did you, how did the readout indicate where the cow had been, do you, do you remember how the output of it was geographical?

I don't think they cared about that. Because the cow, the cattle were confined into chosen fields, and, as long as they were in that field, they didn't mind all that much where... They assumed the cattle, the animal would move to the region where the grass was best for eating.

[04:04]
Yes. Now, a comment that confused me a little bit in the autobiography was that, linked to this pack on the, on the back of these animals, you say that you therefore have played a small part in leading to the removal of hedgerows?

Mhm.

And, I couldn't quite see the obvious link. Why, why had that piece of, piece of technology led, in however small way, to an acceleration of hedgerow removal?

Well, the English countryside that I described in my pre-war voyages by bicycle around it was, as I said, a glorious garden. World War II forced an enormous change. We had to plough up land that had never been ploughed up for years, to grow food to feed ourselves. And I think even then ploughing up everything that we could practically, we still only got about sixty per cent of what we needed. And we survived the rest of the time on what could be imported. And this fills me with dread for the future. When the idiot politicians are allowing unlimited immigration, and, some reckon before too long we may have another ten million in the country, and this is far more than we could possibly grow in these islands to feed. I know agriculture's better now, but there are, are limits, and there's less land available. And, it's a serious problem. So what happened was, the beautiful countryside vanished and the, the food which hitherto had come from distant places like New Zealand and whatnot, had to be grown here on, on the spot. And, this was all part of that process, the improving the efficiency of cattle-grazing. But it also meant the same people working there were arguing for the removal of all of the hedgerows, because they impeded the efficiency of farming.

Mm. So it wasn't as if, for the cow tracking experiment to work, you had to remove hedgerows.

No.

You just felt that you were part of a much wider...

Exactly.

...system of agricultural improvement...

Yes.

...by working on this. I see. Thank you.

[06:27]

Now, Mill Hill Institute, 1951 to 1956.

No, 1951 to 1961.

'61, thank you. Work on...

All sorts of things.

All sorts of things, including cryobiology.

Yup.

Now...

Well that was why I was called back there. [pause]

Go on.

Well I wasn't quite called back; it was the way things worked. I said to Sir Christopher Andrews, 'You know, I think I've really, have just about come to the end of work on transfer of infection in the common cold, and I think it's time for a change. You won't mind too much if I approach the director,' that was Charles Harrington, 'and ask if I can have a change?' He, he was very disappointed, because we got on very well. And I think I mentioned, he used me as bait, because he was a keen amateur entomologist, used to, we used to go walks in the New Forest and I'd go ahead and collect the horseflies on me [laughs] and he would pick 'em up with his net. Anyway. No, he was a bit disappointed, but he was a good boss and he went, he, he saw Harrington on his, when he went back to London. And then an almost instant phone call, 'Oh I'm so glad you want to come back to the Institute. I have an important problem that I want you to work on. Will you come and see me on Monday?' And I went up on Monday and, saw him, and, sure enough, this was it. [07:57]
And it was really quite funny. Apparently two biologists at Mill Hill had discovered quite accidentally that frog spermatozoa that they had put in the deep freeze in a

suspension of glycerol in, a solution of glycerol in water, when they saw them, were still swimming around. And therefore they had survived freezing at minus twenty. And this was great excitement. And, being enterprising biologists, they tried it with a few other things, including red blood cells, and, they all survived freezing if they were treated with glycerol. And this was a very important discovery, and it could alter blood banks and everything under the sun. And, naturally the MRC were very interested. And Harrington sort of said to me, 'I need someone like you to work on this problem, to find out what's happening, how the glycerol works and what's the nature of damage by freezing. Are you interested?' And I said, 'Most interested, I'm fascinated. Just up my street.' And, then he said, 'But,' he said, 'it's not only that.' He said, 'They are great biologists,' he said, 'but the trouble is, they're not proper scientists.' He said, 'I doubt if they know one end of a thermometer from the other.' [laughs] That just concurred with my own feeling about biologists. But, they **are** great scientists, but it's a different sort of science from the one that we, physical and chemical scientists do. Anyway, I joined the department, and of course, there was a great deal of suspicion around, because, Harrington's words had probably got around, he may have mentioned them in the hearing of somebody else, to his secretary or something like that, and, [laughs] so I was the spy in the, in the department instead of a welcome new, new face, for quite a while.

[09:58]
Mm. And, I'm right in saying that in this work there was work on the freezing and reanimation of hamsters?

That came later, about two or three years later. One of the lead sort of, enterprising characters in this was a woman scientist called Audrey Smith. She was a very, very competent biologist, and I think at heart she wasn't that bad a woman, but she had a most appalling manner, and people disliked her thoroughly. She was a bit like Margaret Rutherford, do you remember the actress?

Mm.

She was, you know, tweeds and sensible shoes and, very feminist. And, far too anti, anti men and anti thing to be, to be a happy member of the staff of an institute like

the, the National Institute. And, I mean one of her most outrageous things was, she had draped all around her laboratory various size artificial vaginas that were used for collecting sperm from animals ranging from mice to bulls, or elephants. [laughs] And she would proudly show these off to, [laughs] to visiting male scientists. And it was, it was absolutely hilarious to watch their faces. [laughs] You could hear them muttering, 'What a dreadful woman!' [laughing]

What sorts of things did she say that led to her being seen in this way, as, difficult and...?

Well that, I think that incident alone...

Yes. [laughs]

...you can just imagine, but that was, that was kind of characteristic of her way of going about things.

Mm.

She would be very forthright, she believed in... Now, she was in many ways rather like my mother who was equally forthright, and always believed in telling the absolute truth; no matter how much it hurt, or how much pain it would cause, she felt the truth came first.

Mm.

And, if you've grown up with one of them, it wasn't too difficult to get on with Audrey, so, we worked together quite well. She didn't really rile me in any great way. But it... I remember vividly after one colloquium, one of the things about Mill Hill was, every few months you had to give a public lecture on what you had been doing, your research, it was one of the demands. And it was a very good way of keeping them on their toes.

Mm.

And, we had given one, Audrey had talked about freezing these animals, I talked about, what's the nature of the damage of freezing and whatnot. And Harrington called me in to his office just after the meeting and said, 'You know,' he said, 'I wanted to express my thanks to you,' and I thought he was going to say nice words about the lecture I'd given. [laughs] There wasn't a bit of it. He said, 'I don't know how you manage it, but, you are doing a very great service to this institute by getting on so well with Audrey Smith.' He said, 'I don't know how you can stand it. I couldn't work with her for more than five minutes. But,' he said, 'she is a very competent scientist and is bringing a lot of benefit from her, and you are doing an awful lot to keep her here.' It was a very nice... He was that sort of boss.

Mm. Mm.

And it was very encouraging to be told that.

[13:22]
And she is, she was freezing hamsters.

Yes.

And then at one point bringing them back to life by, using a hot piece of metal near the heart.

That's right. Yes.

And...

A spoon actually.

A spoon. And in your...

Heated in a Bunsen plate.

Right. And in your autobiography you talk about this, and your feelings about the injury caused to the hamsters by this process.

Well they were anaesthetised, but, this is not, that's not the point. When they woke up afterwards, if they recovered, they would have a third degree burn over, right over their chest area, deeper than that even.

And, in response to this problem you built a piece of equipment. Now what I'd like you to do if you could, because I notice in the autobiography it said that you built this piece of equipment on the kitchen table at home, and so I thought this might be an opportunity to talk about ways in which work and home interact. And so I wondered if you could paint a picture of yourself at that time, building this instrument of the kitchen table, and trying to include the bits and bobs that you used to make it, the things that you're thinking about, but also any interaction from family in the process as well.

[14:42]
Well any woman that married me had to put up with my nerdish tendencies. I mean it was part of the package. And, when I was about, somewhere in the region of ten or twelve years old I sold my stamp album and bought the components necessary to make a, a, what was then a one-valve shortwave receiver. In those days, back, this would be about 1930 or earlier, you had to make your own components, there was very little you could buy, and I remember winding coils on jam jars, and, making radio frequency chokes by winding enormous lengths of wire around a pencil, and, things like that. You could buy things like capacitors, and you had to buy the electron tube. And I made it all. And to my delight it worked, and I was able to hear the American radio station, I think it was Pittsburgh WLWO. And, all of the European ones here hit the ranting and all the rests of it. And, one special day I'll never forget I brought the whole family in, because there was an Australia VK2ME coming in, just with this little home-made bit of gadgetry. Now, nowadays you wouldn't think anything of it.

Mm.

But then, it was, you know, something really special, like going out exploring the Moon or something.

Yes.

And... So, that was deep in my mind, was, how to make electronic equipment, and, the results you could get from it. So, the chance to bring home the bits and pieces of a radio frequency transmitter that would be, serve as a diathermy apparatus, was to good to be missed. I didn't want to be paid to do that; I'd spent my own money going down to Lisle Street and buying the bits and pieces, it cost almost nothing, I'd got a surplus RAF radio transmitter which operated at about 100 watts power output for about ten shillings, something like that, but they were almost giveaway things in Lisle Street in those days. And, it was no trouble sort of, re, re-engineering that on the thing so that it fed its output into either a heating coil or capacitor plates into which the animal was put.

Mm. And...

And that brought him alive without any burns or anything.

Building this thing on your kitchen table at home, were your children around you there?

Oh no. No, no, they never... My children had lived... As you probably gathered, I'm a bit of an individualistic person, and so are my children, still are, they all go their own lives, they don't interact much with anybody. It's probably some sort of autism or something like that they'd put it down to. I don't know. It's just how we are.

Were your children perhaps... perhaps the... You've got an older son haven't you?

Yes.

Not interested in what you were building, or making, or...?

Not particularly. No, they would be doing their own things.

[17:52]
And your wife at the time, Helen, what was her view of you...?

Very tolerant.

Mm.

We lived at that time in a fairly large house in Finchley, West Finchley it would be, near, not far from West Finchley Tube station, in a road called Westbury Road. And, it was four bedrooms and, a Victorian built semi-detached, in a fairly quiet, nice suburb. We got it, it was about £2,800, because, it, it was badly damaged, and, [laughs] I, I took it because I liked it, but couldn't afford a surveyor to check, and then discovered after we'd bought it that it had got almost every fault, dry rot, subsidence, God knows what else. But anyway, we couldn't have afforded any more than that. We'd used up every bit of capital we'd got to get a ninety per cent mortgage on that, so... You know as well as I do what's involved.

Mm.

And, with dint of hard work ourselves, we cured all the... and the help of a very friendly builder that we got to know, that my wife's sister happened to have had as a boyfriend or something at one time, that kind of family thing, he showed me how to, by being his mate, and paying him a reasonable sort of sum, we could repair the foundations and dig down underneath and cure the subsidence and all, all the other problems.

[19:29]
At about this time, I know that it was while you were abroad for a year in Boston, you talk about your wife, Helen, typing an essay that you were dictating on ageing which you submitted for a competition.

Yes.

So, that made me wonder whether, what Helen's role was at this time in supporting your scientific work, which I know was at Mill Hill.

None, almost none. [pause] Well she had her hands full, I mean there were three, three children then.

[20:05]
Mm. Thank you. [pause] Now I think the reason that I said 1951 to 1956, and you corrected me, until 1961, is because, you moved into building detectors in 1956, would that be a correct date?

Mm. That's right. And that was still at Mill Hill.

Yes. And so, I wondered whether you could now talk about the argon detector...

Oh yes.

...which was, I think one of or the first detector that you made, which runs alongside a gas chromatograph.

Yes.

So, could you describe the, what it looked like, how it worked, why you made it?

Certainly. Well it all started with the freezing you see. I had reached a point in the freezing work where I knew that the damage done to cells by freezing was caused by the concentration of the salts and the medium around the thing, not by ice crystals penetrating anything. And I knew that the damage was being done to the membrane lipids, they're the fatty materials that keep a cell contents separate from the medium around them. And something happened to these when the salt concentration went up. And this seemed to vary from cell to cell according to the degree of saturation of the fats in the cell. For example, fish living in northern arctic oceans tend to have very unsaturated fats, that's why they, you see them in all the health food stores and

whatnot, the polyunsaturated, omega-3's and all the rest. That, they produced these mainly because they had much lower melting points, and therefore the membranes don't stiffen up when the, when the parts of the fish get very cold. And, a contrary, things growing in the Tropics where it's very hot tend to be full of saturated fats, like coconuts are, it's almost, that's, coconut fat's about the most saturated fat there is. And it's quite harmless incidentally. [laughs] It feeds the people who live in that... That's again a lot of nonsense, that polyunsaturated versus saturated fats. Still, that's an aside.

[22:23]

Anyway, I wanted to analyse these things. And I took a... I knew that Archer Martin and Tony James, two members of the staff, had just invented the gas chromatograph, which was an incredibly important invention, it revolutionised chemistry, and, all the rest of it. And Archer Martin of course had invented all sorts of other forms of chromatography, and got a Nobel Prize for all his work, richly deserved. He was a very man, and, very odd indeed. It's a classic example to modern people. I think, he got his Nobel Prize on three papers, none of which he had written. He hated writing papers. He was even more dyslexic than I am, and found great trouble, and, he was joint author with various other colleagues, and that's how he got his Nobel Prize. So you don't need a great stack of [laughs] papers in order to do well.

Mm.

[23:20]

It's... Anyway. I took it up to them, and said, 'Do you think you could analyse these lipids for me?' And they said, 'Oh yes we'd love to.' And they said, 'Show me your sample.' Now I showed them, and then Archer's face... But I said, 'What?' He said, 'How much is there?' I said, 'About, oh, 100 micrograms.' He said, 'Not a chance.' He said, 'We'd need several milligrams to...' And then I thought, oh my God! that'd be three months' work. And then he sort of, his face lightened up a bit and he smiled at me and he said, 'Of course you could invent a more sensitive detector for our gas chromatograph.' [laughs] And, that was, that was a challenge I just couldn't resist.

And where did you build this detector?

In, in my lab. I had a lab on the second floor of the Institute, in the department of experimental biology. I'd been spending the previous five years as a biologist, working on biological problems, with Audrey Smith, Alan Parkes and, a group of other, quite eminent, biologists.

And what did this detecting device look like as an object?

I can show you. Well, I won't at the moment, but, there's one over there somewhere. I can show you afterwards. They're very simple. Now, it's a simple cylindrical metal vessel, into which gas could go, coming off the pipe to let the gas in off the chromatograph column, and an exit to let the gas out. Inside the cylinder was a radioactive source. And if you chose the right gas to move the components down the gas chromatograph column, the radioactive source would ionise the gas in the chamber, and you could do things with the electrons and ions that were produced. And that's where I came in. And, completely by an accident. It's one of those lovely bits of, [laughs] sort of scientific history. I had a technician at that time, and, I had run out of, I was using nitrogen as the carrier gas because, you can't use air, because it would oxidise some of the compounds, because they were being chromatographed at 200 Celsius, and, nitrogen was available in cylinders regularly. And for some reason the Institute had run out of nitrogen cylinders. And this technician came back and said they hadn't any nitrogen, but would argon do? They had a cylinder of argon. And I hadn't even realised that one of the rare gases was available in cylinder form, because I was unaware of argon arc welding, which goes on quite a bit. And it was exceedingly highly purified too. So, I thought for a moment and thought, oh well, this will probably do for experiments as well as nitrogen. It's free of oxygen, that was the only thing that mattered. And I tried it, and to my amazement, I had been getting miserable little signals with nitrogen from the device, they were huge signals. And, it had all of the sensitivity that Archer Martin and Tony James wanted, and enabled their gas chromatographs then to solve, not only my problem, but half the problems that were queuing up at the Institute. And in no time we had it working. It was on a routine basis. It was running twenty-four hours a day, analysing people's problems. And, in no time at all, instrument companies heard about it, and there was a constant stream of instrument companies coming in. MRC was a bit, and the Government, were a bit wiser by that time, and they insisted on patenting it, which they did, and the

argon detector was patented. And, we were free then to talk to the instrument companies, provided that they would pay, you know, take up the patent and pay royalties on it. And the one that eventually did, and went solid on it in Britain, was WG Pye at Cambridge, which was in those days a British firm. They were marvellous, they built a very good chromatograph incorporating the argon detector, and sold it worldwide. And, it was quite a bestseller as instruments go for about two years.

What was the name of that instrument, the Pye?

I think called Pye argon gas chromatograph, or something like that. I've no idea the exact name. But... And that established gas chromatography in important fields like lipid biochemistry, because they are volatile things, the lipids, you can do... And also, the petroleum industry and chemical industries where they make... You see for the... [28:05]

I'll never forget going to Houston, carrying an argon detector in my bag, and breaking all the laws of America, taking radioactive material across frontiers, but nobody detected it anyway, [laughs] and a capillary column, which was a highly resolving column, and setting it up in the lab, in the lab of a colleague in the University of Houston. And there was a queue of petroleum chemists from all the refineries around to come and see this wonder. It was one of the most exciting moments I have had in a scientific lifetime, because, you could put a sample of petrol on the chromatograph, gasoline over there, and it would separate it into all of its components, all of them, the whole darn lot. And all of the peaks would come out on, on the chromatograph. And, there were cries of, 'Oh so that's where the iso methylpentane goes.' I don't know, I'd say, 'And here's trimethylcyclohexane,' and, the things that there was no way before they had any possibility of identifying, were all spread before them. [29:14]

So it was a very important instrument. And then, within a year it vanished. For two reasons. One is, the Greens didn't like it, because it had radioactivity in, and tried to be difficult about it. And secondly, because, somebody invented a slightly better detector called the flame ionisation detector. That was invented by a pair of South Africans, Harley and Pretorius. I got to know Victor Pretorius, he became quite a friend. And, I, I mean, I wasn't all that bothered, because I recognised it was a better

device, and I was getting a little bit too heavily involved in fending off wallet-bursting instrument companies who wanted a piece of the action. And I gave up several opportunities to become a millionaire several times over, they wanted to be partners of their companies and things like that.

[30:10]
Why did you not go for that?

Because I knew immediately, if I did, I was wise enough by then, I was only in my thirties, to realise that if I joined up with one, Keene Dimick for example, who had a company called Varian Instruments, he wanted me to be a partner, that, all science which I wanted to do would be subjugated to inventing the kind of things he wanted for his chromatographic firm. And, it wasn't what I wanted to do. Actually, I would have... I did lose a lot of money because, he sold out in two years to Varian Instruments for $20 million, and if I had been a partner I would have got at least a third of that.

Mm.

So, it's... But, it's a choice you have to make I think fairly early on, and, which route you want to go. And that, that was a rather crucial thing. So it was quite a serious thing.
[31:05]
But then, when I went back to Mill Hill after these visits to America, I got involved with the electron capture detector, and of course that turned out to be far more important in many respects.

[31:20]
Yes. Before we talk about that, can I pick up on a couple of things that you've mentioned that will just help the...

Yeah.

...the listeners to understand. The first one was, you said that when you hit upon this lucky experiment in using argon instead of nitrogen, you said that before you were getting tiny signals, but with argon you were getting huge signals. For someone who doesn't...

About 1,000 times greater.

But for someone who doesn't have the equipment in front of them or know how a chromatograph reads out, people, someone like myself for example, what, what were the signals that you were reading, or not reading, or getting bigger ones with the argon, what was, what was the nature of the signals, what did it look like?

Right. I was putting... When I was passing nitrogen down the chromatograph column, and to operate the instrument you had what's called a microlitre syringe, it was a tiny hypodermic syringe that held one or, anything up between one and ten microlitres of liquid in it, you drew up, shall we say, a couple of microlitres into it, and injected them onto the gas chromatograph column. You might ask, why for greater sensitivity couldn't you use a much larger amount? The reason being that then, the resolution of the column would be blinded and you wouldn't get any separation; you had to use small quantities to get good separations. So, now when I did this, with the nitrogen flowing, there were tiny little peaks appeared on the chromatogram for each of these substances.

Mm.

Just, just, the pen rose just above the baseline and then back again. And there was a lot of noise, so the smallest peaks were hidden in the noise. When I switched to argon, the peaks became 1,000 times bigger, but the noise level was no more than it was previously, before. So here, a very small amount, a tenth of a microlitre, would give a huge chromatogram.

Why, why were the peaks greater using argon?

Because, in many ways, although I hadn't realised it when the accident occurred and I used argon instead of nitrogen, using argon made the detector I had invented rather like a laser. Whereas the nitrogen was just an ordinary light in a sense. This is an analogy to think of. The argon atoms were, as a result of the potential put across the detector from the, you apply a voltage to it to get it to work anyway, were pumped up to what's called the metastable state. That's a quantum state called the triplet state of argon, which isn't ionised, but it's just an atom of argon that's highly energetic. Now when that atom bounces against a molecule of organic stuff, it ionises it, and then turns back from ordinary argon atom. But you keep pumping them up so you've got a constant number of metastables and the vapour comes in and gets completely ionised, but no other ions are produced than due to the presence of the vapour molecules. So you then have a high, an enormous amplification of the signal that you were getting with nitrogen.

OK. Because...

Noise-free amplification, that's the important thing.

Because... It because the, the vapour, the material of the vapour, through being ionised, in some way therefore produces a bigger peak, because it's...?

Well the way the peak is produced, you have a potential across the detector, and you, you measure the current that's flowing through it. Now the more ions produced, the more current. So the bigger the chart deflection which is telling you how much the current is against time.

Thank you.

Well I hope that's clear.

[35:08]
Yes. Yes, thank you. And, the chromatograph itself, could you describe, in really simple terms, what the output is like. Is it on a paper roll, is it on a photographic chart, what is the actual output like as a physical object from the chromatograph?

Well in those days they had what were called chart recorders. These were things that you put in a roll of paper which was about A4 width, like that stuff.

Yes.

And, a clock mechanism sort of, drove it on continuously through this chart recorder. And there was a pen that was usually set on one side of the chart that just ran along and drew a straight line. But if you put a signal in, then, it would move upwards on the chart, and then go back to the straight line when the signal had gone. And the chromatograph signal was a peak that came up, reached a top level and then fell back again. And the heights of that peak or the area of that peak was a measure of the quantity of substance that had been detected.

How did you know that one particular peak was a particular fraction of a, of a chemical, rather than another fraction of it?

Good question. Mainly by calibrating. The time was fairly precise that the stuff came through, and it was called the retention time of the column. And it might be that the retention time for methyl palmitate, which would be a typical fatty acid ester, was as long as twenty minutes, so it was quite a slow process sometimes. Shall we say it's twenty minutes. Well, you would know that the peak that came out at twenty minutes was methyl palmitate, especially if you've got a mixture of fatty acids, and you would calibrate it with all of them, and you had included methyl laurate which is C12, methyl myristate which is C14, and methyl palmitate, C16, methyl stearate, C18, and so on, and you, you knew the positions of those peaks. And typical, natural lipids had a very characteristic pattern and you soon got to recognise differences.

Mm. Did you have to calibrate that for each instrument you used, or could you just use a manual that said, this chemical will take this long?

Nnn... You could, but, you wouldn't ordinarily rely on it. You calibrated each column.

Thank you. And...

The columns lasted months mind you.

[37:45]
Mm. Thank you. And, you mentioned that the Greens were difficult about the argon detector.

About radioactivity generally. They were difficult about the electron capture detector too.

When you say the Greens, who are the, which particular groups or people or individuals are...?

Well, the Green movement's a peculiar movement. It started off by straightforward what we call naturalists. I was one myself, very much so. And, in many ways Rachel Carson marks the boundary between the old Green movement which was people of, everybody going on, coming on all through the Victorian times and right up until recently. Rachel Carson was the first one to suggest that the products of chemical industry were beginning to contaminate the natural environment. You see before that, pollution had been a city problem, affecting people living in cities, and you didn't think of it as going out into the natural world. But Rachel Carson suddenly opened our eyes to the fact that, pesticides and things like that, products of the chemical industry. This immediately drew the Left in, because any stick with which to ht the big chemical industry was, fitted in beautifully with what I call primitive Marxist thinking, that all big manufacturers are evil people out to grind the faces of the poor and so on and so forth.

Mm.

And, the Green movement became politicised then as a kind of anti-industrial Luddite movement, and, it soon merged with CND, the Campaign for Nuclear Disarmament, which again had very honourable origins, with bodies like Pugwash and so on, that saw the evil of nuclear weapons and wanted to... but rapidly became diffused into a

kind of left-wing anti-industry movement but being particular anti-nuclear industry movement. Which really, although at first it had a lot to do with weapons, developed as a source of energy primarily, and, so the objection became negative. But anything radioactive gradually in the public's mind became filled with danger and threats and, one, nowadays there's the story of dirty bombs, some terrorist wrapping any ordinary explosive in radioactive material, they think of that as deadly and terrible. If you talk to the police and security organisations concerned with that, they will tell you, their only concern with it is people being hurt by the bomb, the explosive of the bomb itself; the radioactivity is a minor problem.

[41:31]
And, how were you aware that the Green movement didn't like the argon detector, how did that become apparent?

Mainly from sales reps, for companies dealing with it. I mean, I had a fair amount of interaction with the companies. When I left Mill Hill and went independent, one of my supporters was Pye Instruments, and, that was before they were taken over by Philips, which was a rather brutal takeover. Very typical of a European takeover, but I can go into that elsewhere. And... But the sales reps were saying, 'Well we, we couldn't sell it there,' because there was some Green who was objecting, 'got radioactivity, it's too dangerous, we're not having it in the lab.'

OK. So it wasn't as if it was rejected by a particular organised group of...?

Well there's also lots of Green legislation. You couldn't handle any radioactivity, with all sorts, without all sorts of restrictions, which have steadily become worse and worse and worse as time has gone on. And, an awful lot of money gets wasted dealing with them, so that, companies don't like to have to deal with it.

[41:55]
Thank you. Now, yes, we are getting now to point when you're, you're going independent. And, could you give the date of your move to Bowerchalke?

That was not going independent. [pause] The first thing we did in Bowerchalke was 1956, when, with a colleague of mine... [pause] Nash... One of the troubles with ageing, you forget names properly. What was his... [pause] I can't remember his Christian name. Anyway, he was Nash, and I, decided to buy a cottage in Bowerchalke called Pixies Cottage. And it was £2,000. We, I hadn't anything like that much cash. He had a fair amount of cash. So I said, 'Well let's do a halfway split. I'll take on a mortgage for £1,000, and you put up the cash.' And this is what we did. And, it worked quite well.

And then...

We used it as a kind of weekend cottage, holiday cottage and all the rest of it. Nothing... Oh Thomas Nash it was, that's right. He regarded it as a good investment, in property, which it was I suppose, in those days.

And this was a, a village that you had visited on a cycling holiday right back when you were working with the...

In 1936, yes.

[43:27]
...with the firm. Yes, in... yes. And, I wonder whether you could comment on what, at this time, at the time that you decided then to part-buy this, at this time, what was it that you liked about the particular village and the particular house, in terms of privacy, in terms of kind of an interesting rural privacy?

Oh the house itself was the only one we could get. They, they rarely ever became available. And it wasn't the most suitable in many ways. It was a nice looking little cottage, but it was a bit impractical. It wasn't very big, and it had cob walls that were always giving problems, and a thatch roof which would ultimately give also, all sorts of problems.

Mm.

But it, it did very well as a foothold. And, the main attraction was Bowerchalke itself, and the county around it. It was gorgeous country. It was on the edge of Cranborne Chase, which was rolling woodlands, un, unspoilt woodlands that went off in all directions for incredible distances.

Mm.

And you could do a ten-mile walk along the Ridgeways, partly through Cranborne Chase, to the highest point around there called Win Green. A lovely walk, and one, one frequently did it. And the village itself was extremely pleasant. It was one of those old-fashioned English villages, full of villagers. There were about four or five farms, not all that big, the largest one would be about 600 acres I reckon, that worked out of the village. And the people in the village were farm workers mainly, or... and farmers. And the servicing people that, there was the village shop which was a very good one, a post office. There was even a village dentist, retired, and in the next village down, Broadchalke, there was the physician, the GP, for the area. And, there was a garage in Broadchalke, and, a butcher's shop, and there was a baker's shop in Bowerchalke. So it was a kind of, very much a country, old-fashioned community. And there was a bus that ran into Salisbury that was driven by a bus driver called Wes Pope, who was quite famous because he'd stop off and have affairs, have it off with his inamorata along the route, [laughs] and the villagers just sat and waited, [laughing] sort of, dropped off. Ah dear me. It was wonderful, it was like, you know, one of the novels there were around, well, *Cider With Rosie*, that kind of thing.

Mm.

And, it was a lovely life. And it all lasted until about the, again the awful Sixties. And it all fell apart.

[46:12]
Because of, commuting and...?

No; the first thing that happened was, agribusiness farming. The farms sold up, and they were bought, properties were bought by insurance companies and the like, who

suddenly put in farm managers who said, 'Ah, this is no good,' and tore out all the hedgerows, turned it into one giant prairie with barbed wire around, not hedgerows. And, enormous, gigantic tractors that just ploughed up a square mile of field, that sort of thing. You can see it all over Wiltshire. It, it suddenly changed, almost within a year, from gorgeous, beautiful countryside, to an awful lot of it becoming completely devastated.

Mm.

And that was agribusiness. Needed to feed us.

[46:58]
Back then, around '61 you, you started to think of saving up to establish an independent base, or is that, am I setting that too early?

Not really, no. It, it was... I loved Mill Hill, it was an almost ideal working environment, you couldn't have expected any better. I was free to do any science I wanted, so long as it somehow was connected with medical research. I remember when I started work on the electron capture detector, because I began to realise how important it might be, because, what's special about it is, it uniquely detects that extraordinary sensitivity, 1,000 times more, or 10,000 times more than the argon detector even, only substances that poisonous, or, or a threat to the world in... It's almost the Greens' own device, given to them. And ironically, with a, requiring essentially a radioactive source within it.

Mm.

And, it was that, was... I was able to do that, and I remember going to Harringtons saying, 'Do you mind me working on slow energy free electrons here?' And I said, 'It's got absolutely nothing whatever to do with medical research, and I'm, my conscience is bothering me, am I doing wrong?' And he said, 'Heavens no,' he said, 'I don't mind what you do as long as it's good science. The only thing I worry about is people here doing bad science.' And, so I had a free carte blanche to do what I wanted. I worked four days a week. I took off Fridays always and went down to

Bowerchalke and stayed there, until Monday. Came up on Monday morning. So it's really only three and a half days a week I was at Mill Hill. This was utterly accepted because I was productive.

[48:48]
Where did you make the electron capture detector then, where physically?

First of all, physically, at Mill Hill.

And what...

And then... But it was reduced to practice, as the patent calls it, at Yale University on a sabbatical.

[49:04]
OK. And, could you describe it as a physical object itself?

Almost identical with the argon detector. It was just run under different conditions. Do you know enough about electronics to know about diodes?

I know a little bit about it, but we, I think we ought to assume that anyone listening doesn't.

Doesn't. Doesn't. Yeah, well a diode is what's called a two-electrode electronic device. You have two wires going into it that carry potential or current or both, and, if you put the diode in any kind of circuit, it'll do something interesting. For example, the simplest form of diode will allow the electricity to pass in one direction only. If you reverse the current, reverse the polarity, nothing flows.

Mm.

So you can use one of those to convert the alternating current coming down your mains into direct current, which you need for charging a battery, or something like that. So you've got them all over the place, in all of these so-called power supplies.

There are diodes that are converting the alternating current of the mains into DC. That's one form of diode. But there are dozens and dozens of electronic diodes, and the argon detector and the electron capture detector are kind of, complicated but still essentially diodes, they just had two electrodes, and you put a potential across them, and you observe what current passes.

Mm.

So that's, that's the basic thing. But in the case of the electron capture detector, what it is looking at is the current of electrons flowing across a device, which contains a kind of suspension of free electrons, a bit like a test tube with a solution of electrons in it. And when an electron capturing compound comes in, it takes the electrons away and so the current drops. And that drop is a direct measure of the amount of the substance that has come in. It's absolute, in the case of many compounds. In other words, one molecule means one electron, so if you see one electron less, then you've caught one molecule.

[51:17]
Now, if you've got an air sample and you're putting it into the detector, you may...

You put it into a gas chromatograph. These things always sit at the end... You would never put air into the electron capture detector because all that would happen, the current would drop to zero, because the oxygen in the air would capture all the electrons.

Ah, could you describe the way in which the capture detector works with the chromatograph?

Yeah, you have it at the end of a column. I've got one that was taken on the *Shackleton* that measured the CFCs, that's down in the end room there. They're very simple things. You have a column, and there's nitrogen flowing through it, and you put in a shot of air, five CC's of air, for example, and it goes through the column, and the first gas to appear, because it's, it's not absorbed much at all, is the nitrogen itself, which you don't see because nitrogen's a carrier gas so you wouldn't see a little bit

more. The next one is oxygen, which gives a great big peak, because it captures all the electrons. But then, the oxygen is all swept out, and now you're seeing the things that move along the column more slowly than the oxygen. And the first one you will see with a good chromatograph is fluorocarbon-12 as they call it, that's difluorodichloromethane. And this will give a sharp peak indicating its amount. Then there'll be a gap with a few small peaks which are other fluorocarbons, and also if you live near the sea, methyl iodide and things like that. And then, a little bit further along, the line will rise steeply in the air and a large gloop of fluorocarbon-11, that's the trichloro, monofluoro methane. And then, oh you get a miscellaneous pile, and important among them are two compounds, one is methyl chloroform, CH_3, CCL_3, which was used for many years as an industrial solvent. And then after that, carbon tetrachloride. And then... You can just go on and pick up all sorts of things. And if the chromatograph were running at high temperature, you might even pick up traces of DDT and pesticides and things like that.

[53:35]
How does the, the EC... the electron capture detector at the end of the chromatograph enhance the, the recording of the chromatograph?

Well, it only responds to the compounds that capture electrons. And compounds that capture electrons are very rare on the whole. The great bulk of things in nature do not. The things that capture it, apart from, in the air, normally, very little captures electrons apart from the oxygen. In the body for example, in your body, most of the compounds, the lipids, all of the natural things, don't capture electrons at all. What do capture electrons, interestingly, are the compounds involved in what's called oxidative metabolism, that is, the alternate acids of what's called the Krebs Cycle, that's one of the cyclical pathways that things go through; every other acid of that cycle, substances like oxaloacetic acid, pyruvic acid, fumaric acid, and so on, they all capture electrons very strongly indeed. And so do the thyroid hormones, which are also involved in, in the thing, and the steroids, they all capture electrons. But nearly everything else in the body doesn't. And so, if you put biochemical samples in, you only see those kind of things. Or, poisons. Nearly all of the carcinogens capture electrons. It's as good a test of carcinogens as the Ames test nearly.

Mm.

And, it's very odd, that. I, I remember, I've got it on record in one of my papers, that, whenever I found a new compound that captured electrons, particularly if it was an industrial product, I was a little anxious, and I wouldn't want to tangle with it. And it's very funny that, two compounds that come straight away into that class that were detected fairly on in the ECD, were vinyl chloride, that turned out to be quite a nasty carcinogen later on, and another one was the phthlate esters, which turned out to be interferers of... or, hormone substitutes and things like that. And both of those are strong electron capturers. And, so it, it detects nasties, almost regardless. And it was quite extraordinary that the CFCs, which of course were nasty in a quite different sense, because they're not toxic at all, should be easily detectable by the ECD. So it was the Greens' dream in many senses.

[56:19]
Mm. And when you first had designed this electron capture detector and you were, you used it to measure air samples, what were you, what sorts of chemicals were you looking for initially?

Ah. Well, it was, that leads back. When I was in Bowerchalke first, way back in the 1950s, I noticed that in the summer the air was unusually hazy whenever it blew from Europe. And I got so interested, I got... when I was over in America and visiting the National Center for Atmospheric Research at Boulder, I got the scientists there interested, and they gave me what was called a sun photometer, which is an instrument, you can measure the haze in this by looking at how much sunlight's absorbed by it. And my family and myself kept a record of the haziness all of the time. And some of this work was published in some papers in *Atmospheric Environment* that I wrote about at the time.
[57:21]
And then I kept on wondering, where the hell is this haze coming from, what's the source? And you couldn't just say, well it's coming with the easterly wind off Europe so it must be industrial pollution, because it might have been coming out of the sea, or out of the land, or anything like that. And I thought, well what compound could there be that comes from big cities where people are, that is not anywhere found in nature?

And it didn't take me long to think, CFCs. They're in every refrigerator. And at that time people were using them in spray cans, and they were being poured into the air all the time, albeit in very low levels. Now it would mean detecting them at the parts per trillion level. Could I do this? Yes. Duck soup with an electron capture detector.

Mm.

[58:04]
So I started measuring haze, and the presence of CFC-11, which was the easy one to detect, simultaneously, and soon found a strong co-relation, whenever the haze comes, then the CFCs rose steeply in the air, to a much higher concentration, about three times greater than in the clearer air.

[58:23]
So were you looking for those before you were looking for things like pesticides, residues and...?

I never looked for pesticide residues. It was others using the ECD that did that. [pause] One of the great difficulties when I first made the ECD, I had a vague idea how it worked, but explaining how it worked quantitatively and mathematically was very difficult and beyond me. At first I blundered. I assumed that it worked rather like light absorption, the passage of an electron across the detector so to speak from the, where it was produced at the source to the anode, that's positive electrode. It would be absorbed, in the same way that light's absorbed, when you send it through a spectrometer, through a coloured compound, or absorbing compound. And it would be a logarithmic relationship like the Beer's Law I mentioned about earlier.
[59:21]
And soon experimental measurements proved that wasn't so, it didn't behave at all like a Beer's Law, it was some other relationship. I gave up at that point, I thought, oh I can't really understand this. I had worked out the equations, what happens in the detector, chemical equations, the reaction of the electrons and the molecules and the ions and so on and so forth, but they were what's called non-linear differential equations, and you cannot solve them by ordinary mathematics at all. So I just gave up and say, oh no, I can't do this.

[59:53]
Now, at that time, I was working at JPL, you know, the space lab in, in California. Not... I don't mean working there full-time; I was making visits of three weeks to do projects with them. And so, I got into the computer game very very early on, when computers were written in assembly language, or even binary, and, got a hands-on experience of programming very simple computers. So one of my first purchases as an independent, when I became permanent at Bowerchalke, was a Hewlett-Packard 9800 I think it was, or 9100, desktop... it was, they called it a calculator, but it was a simple computer and you could program it. And I was able to solve these differential equations for the electron capture detector using it. And suddenly how it worked, all the interesting things about it, how it was absolute, and why it was so non-linear and so on and so forth. And, that experience of programming and solving differential equations came in great stead for me when I came to the much more difficult Gaian problem, and it led to the Daisyworld model which...

Mm. Mm.

So it is important, the way all of these things, although apparently disparate, link up together in, in peculiar and complicated linkages. And I think that's the essence of science, and delight of science.

[01:01:30]
Mm. Thank you. Could you describe any interaction between you and your family at the time you were making the electron capture detector? I asked a similar question with the, the heat, the piece of equipment you made for re, reanimating organic material. Some of this detector was built at Mill Hill.

Mhm. All of it.

All of it entirely? OK. And so, were you discussing what you were making at home?

Helen was not very interested in the work I was doing, and neither were my children. And, I was quite content. I was content to live my life at home in one compartment and my life at Mill Hill as another. My second marriage now with Sandy is totally

different. We work together almost totally. It's a, it's a, it's a proper loving relationship and it's fine. But, I think, Helen and I made a mistake when we married each other. We were not, we were attracted but not really suited. And I think it often happens with young people, doesn't it, that sort of mistake? And in our times it was not easy to say, after six months, 'Well this is not going to work, let's go apart.' In those days marriages were far more permanent commitments and you just couldn't break it.

Mm.

And you had to soldier on.

So when you came home and said, 'I think I've developed something that very very sensitively measures dangerous atmospheric chemicals...'

Never men... that was never mentioned, ever. [pause] But, what would happen was, other scientists would come and visit and stay with us, and, they would talk about it, and, Helen would be drawn in to some extent then and might even say, 'Well you never told me you were doing that.' And I'd say, 'Well I didn't think you'd be interested.' Which was true enough. I mean there wasn't any, anything very negative about it, or... It was just the way it happened.

So while working at Mill Hill, to what extent did you bring work home in a way that would be visible to your family?

I didn't. I didn't bring work home, to any great extent. That, the example of the diathermy apparatus was pure nerdishness. I'd been building radio receivers since I, I was eleven, [laughs] ten or eleven years old.

Mm.

And, chance to do some fiddling around with a soldering iron and a few bits of wire and things like that was eagerly seized on by me as a kind of hobby if you like. And, that was easy. But ordinarily... And any case, I couldn't bring an ECD home, I

couldn't. I mean, I didn't regard the radioactivity as all that dangerous, but I thought it would cause the most fabulous fuss for scientists to be found with dangerous quantities of radioactivity in home environment kind of thing. So, it didn't occur to me ever to want to do it at home.

[01:04:36]
What about, what about writing and, and thinking and...?

Oh writing, that's totally different. I did a lot of that at home. I had a room set aside at the last house I had in Finchley, an office, in which I did a lot of writing. But that was more during time off. I never wrote in the evenings. My... I'm a person that is most active and alive in the morning, and least as the, the evening draws on. So, there was no incentive really to do it. No, my home environment was very, pretty well complete. I, I would hate to give the impression it was a bad married relationship, it wasn't. It wasn't, just didn't have the intense quality that my second marriage has had.

Mm.

[end of session]

[End of Track 5]

[Track 6]

I was telling you about the home-made diathermy apparatus I built on my kitchen table in Finchley, in order to try and revive the frozen hamsters without giving them horrible burns. And this is it, you can see, it's very crude and primitive. Those are the two transmitting valves. I think they were of German origin, surplus German Telefunken valves they were. And there's the, the oscillator coil, and behind it somewhere there is the capacitor that you can vary to tune the coil. And it, it just oscillates at about, somewhere in the region of thirty megahertz. And, there's the... Because this particular thing runs at rather high voltages, probably 500 volts DC, or even higher, it might have been 1,000, I've forgotten, a long time ago, they're not very safe to handle. So, the radio frequency, the heating energy, was drawn off down this coaxial cable to a separate resonance circuit here, which could be held at earth potential, there's no risk of earth DC shock from it.

Mm.

And, the proof that it was resonating was either made with this little loop which had a light bulb in it, and you just put the loop near it and the bulb lit up, and you tuned it until it was maximum brightness, and then, this was working, or there was a little capacitance here. Sorry, not a capacitance. A, a neon glow tube. And, this lit up when the, the capacitive plates for heating the animal were energised so to speak. So that when you put the animal in, it might alter the resonance a bit, and this would stop glowing so you could tune it up so that it was glowing again with the animal there.

Ah, I see.

It was all very simple, primitive stuff, but it worked, worked fine.

And the animal went in, onto the plates...

Just in between those two plates.

In the bottom left-hand... Yes.

That one and that one. Yeah.

[02:18]
And in the background, in the middle of the photograph behind...

That, that is a power supply.

Ah. I see.

A big transformer and a rectifier valve. And that's probably a capacitance, I'm not quite sure what, performing some other function.

And what was the role of the stopwatch that we can see in the foreground?

Oh, well, that was used by my colleague Audrey Smith for timing how long she kept the, this thing going. Because that was fairly important. You didn't want to overheat it.

[02:50]
No. How long would it take to reanimate a, a hamster, using that piece of equipment?

Minutes. One or two minutes, that's all.

Mm.

You see, you're putting, I forget how many watts, it might have been... hundreds of watts of energy into the thing, and it's not very big.

Do you remember Audrey's reaction when you produced this piece of equipment as an alternative to the...?

Oh she was quite enthusiastic. She was very good that way. And, she didn't take it amiss that I was a bit soppy and didn't want to see the animals hurt. Well of course

biologists are... That's one, another thing I had against biologists, they're incredibly cruel with... They seem to have almost a mediaeval attitude to animals, well they're not sentient like us so it doesn't matter. I mean hence Victorian vivisection and all the rest of it. I could never... It was absolutely abhorrent as far as I was concerned, always has been.

And was Audrey herself concerned about the, the piece of hot metal you used previously to this?

No, as long as it did the job, answered the experimental tests, that was it. I think, there was a general kind of feeling amongst medical biologists and biologists generally that the animal world, everything outside, is there for you to experiment on. There isn't any... It's a bit worrying. Maybe it's all changed now, I don't know, because this was a long time ago. This would be about 1954.

Mm.

Or even '53, that, that was done. This was all written up in the Proceedings of the Royal Society, and, the papers, they have got pictures of this equipment. [pause]

Go on.

[04:40]
Yes. As the thing proceeded, and we became very proficient at freezing and reviving these hamsters, and finding out all sorts of interesting things about life in the frozen state, we, then the question came, would it be applicable to a larger animal, even humans? And the first steps towards this were to take the smallest primate that was available, an animal called a galargo, and, there is one, that had been cooled, I think to nought. It hadn't actually been frozen, but it was being, now being warmed up from nought degrees in a very much larger diathermy apparatus. This time the heating was done by induction. Those coils were set in resonance, and there's our neon tube again I think just down there to show the, the resonance. And, that sets circulating currents going inside the animal's body and that heated it up, the capacitance one; it's using animal more as a dielectric and heats it, that, by the electric, oscillating electrical

field. But it worked. It warmed the animal up all right. But unfortunately we could never get galargi to revive, to come back to life.

Why do you think there was a difference between hamsters and, and those particular animals in that...?

Well one of the legends is that hamsters were a remarkable animal that were first, a pair was found frozen at the top of Mount Ararat. [laughs]

Ah.

And descended from that. Well of course leaving that fiction aside, [laughs] they are an animal that must in its natural environment have got very close to nought, or even below it, in hibernating. And, whereas galargi were much more tropical animals and not sort of encountered those cold environments. I, that's guesswork, I don't know.

[06:40]
Yes. And the, on the left we can see someone holding a, a pump, what's that?

It's a, it's just an air pump. I don't know, to be quite honest, what they were doing with it at that time. It was obviously for some reason connected with the revival, or, or not, revival's the wrong word, reanimation of the animal.

Mm. And at the other end, there's some sort of shiny cylinder being held is there? And do you know what's happening...?

No, I wouldn't. It's too long ago, I've forgotten the details.

Yes. Yes.

But this was quite an operation to, to go through the whole thing. And...

And once you had found that this animal couldn't be reanimated, did that put an end to thoughts about freezing and reanimating humans?

Well not only that, but I had a paper in the Royal Society... No, no, it wasn't the Royal Society. It was the New York Academy of Sciences, in, I think it was 1958, explaining why it would probably be, always be impossible to freeze and, and reanimate a human.

Mm.

It's just a matter of heat content. You know how long it takes to thaw a turkey, or to, or freeze one come to that, and, you can only get tissues to survive low, very low temperatures, like minus eighty or minus 180, liquid nitrogen, by rushing them through the intermediate range, nought to minus thirty, as, in a matter of seconds. Well you can't do it with a large animal like a human. No way. And if you don't, then, the cells are all destroyed during their passage through that. [pause] And I'd better not that because we're going to put these all on your disc.
[08:48]
This piece of apparatus is the home-made chromatograph, a gas chromatograph, that I took with me on the research ship *Shackleton* from Barry in Wales down... The ship travelled right the way down to South Georgia in, in Antarctica, and around the Antarctic Ocean, down there, during the winter, and then made its way back to Britain. It was a six-months journey. And it took samples, this apparatus was used to sample the CFCs and other gases in the air throughout the whole of the, the voyage, and it was the one that provided the evidence, the firm evidence in a *Nature* paper describing the results of the voyage that set off the ozone, ozone depletion by chlorofluorocarbon environmental interest of the 1970s and '80s, that led to the Montreal Protocol and the banning of the emissions of CFCs. But it was a very simple piece of apparatus that varies an electron capture detector just held inside a, a thing, a clamp. And, here is the gas chromatograph column. Nitrogen entered from a cylinder at this point at a pressure of about, ten to fifteen pounds per square inch.

So that's the top left. It comes in at the top left there, yup.

Left, the top left there. Oh yes, they won't be able to see the cursor. And, then passes through the column into the detector. What you do is, you take a five millilitre glass

syringe which is ultra clean, you've made sure of that, and go to the bowels of the ship, and then put your hand and the syringe out through the anchor hole, so that you're in the clean air coming along with the wind blowing. And then draw air into the syringe up to ten times to make sure it's absolutely a clean sample of the air. And then you just stick the point, the needle of the syringe, into a small stopper, a rubber, soft rubber stopper, just to stop any mixing with air on your way back to the lab in, in the ship. And when you'd got to the lab in the ship, you inject that five millilitres of air into, through a, a septum it's called, it's a silicone rubber stopper, just there, onto the column. And then the nitrogen carries the air sample through. The air itself, the nitrogen and oxygen, goes straight through quite quickly, but the chlorofluorocarbons are delayed, so, they come into the detector as pure substances free of oxygen and nitrogen, and are detected.

How long roughly do they take from the top left through the coil to reach the detector, those substances?

It varies. The oxygen will be through in about, oh, thirty seconds or less; but the, the CFC-11, the one we were mainly looking at, took about two minutes.

[12:14]
Mm. And then, once it's reached the detector, which is the, the small instrument suspended on the top right of the apparatus...

Mm, yes.

That then seems to be connected by an electrical wire to the box that's at the bottom right of the picture. Could you explain the link between the detector itself and that piece of equipment at the bottom?

Yes. In order to detect the reaction inside the detector, between free electrons, that's electrons that are floating in a gas at equilibrium with the gas, just as a chemical. They really are a chemical. They're not only an object of physics, a fundamental particle, they're a fundamental particle of chemistry and biology. And the free electron is a tiny free radical, it floats about, and it will react with some things. But it,

it's fussy, it only reacts with [laughs] things that are environmentally interesting, for some reason. And, when a CFC for example enters the detector, the first electron to see it joins with it, reacts with it, and causes almost a fission. A chlorine negative ion splits off from the CFC molecule and then, neutralises itself by meeting one of the positive ions that are also floating around in the detector. So, that's taken away the electron altogether, it's out of the, out of all thing. And then, at every 250 milliseconds with that detector, a brief sampling pulse lasting only one microsecond long at forty volts is put on, and that does the job of taking all of the electrons that haven't reacted out. They go down the wire back into the amplifier here, and that's, that's the signal. It, it tells you the number of electrons that are left after the CFC has entered, and is a measure of the amount of CFC, a direct, absolute measure, because it's one electron per molecule. And the... well, it wasn't quite, Coulomb's law, tells you that, in that case you could, if you know the current you... over... when... that's passing through the detector in the form of electrons, you can calculate exactly how many molecules of CFC there were in that 5 cc's of air you injected.

[14:58]
And I understand that there was a piece of recording equipment attached to this, which showed you that result.

Yes.

Could you explain where that was attached in relation to this picture?

Well it was attached to the amplifier section, this brown box down at the bottom right-hand side. And, the connection is not shown there, because it's been separated, just for show. But, there was no, no great problem about that. The recorder was the standard industrial instrument. They were usually used for recording temperatures, anything like that. And there was chart paper that reeled off from a chart, and a pen that ran along the edge, and if a CFC came in, then the pen would be deflected outwards and would leave a trace which formed what we called a peak, a peak being a signal of a CFC.

[16:01]

And how would you be able to count the number of electrons removed? When you said there was a pulse and the electrons left, quickly went down the wire back into the box and you could...

Well you... After you had passed the sampling pulse, a kind of dipstick, how many electrons are there now, you then left it for 250 microseconds, that's 250 times as long as the pulse, and the electrons built up again to a new equilibrium amount. And then, at the next, the next pulse would find out how many were still left. And so on, you kept repeating that.

[16:40]
Thank you. And the first thing that you said, the first stage of this was to make sure that the, the tube that you collected the air sample in was clean.

Yes.

How did you make sure that that was clean, the tube itself?

Oh well, if you want, what you do is, the usual procedures, you, you thoroughly clean the glass. If necessary, if there's any reason to suspect it's dirty, you use some fairly strong oxidising agents to get rid of any organic matter or anything that may be hanging around, and then wash it with a, a very clean supply of water followed up with the ionised distilled water, and then just leave it to dry. And, the final cleaning is, rinsing the syringe thoroughly through the hole in the front of the ship with the clean air coming from the front of the ship, due to its motion through the water.

Mm. Mm.

[End of Track 6]

[Track 7]

What we have before us here is the bench on the research ship *Shackleton*, and being a research ship, it had the usual three-pin plugs, ample supply of them with the 240 volts from the ship's generators available. Very stable, good supply, because it's a research ship. And, here is the apparatus I showed you before, the chromatograph column. This now joined up to the nitrogen cylinder which is a forty cubic foot one you can see just behind the...

Oh yes.

...the apparatus. And, there's just a digital volt metre, an early one there, which was just for me to have a, keep a check that the whole thing was working properly. And, and there, joined to the amplifier is a chart recorder, and you can see the pen is partly reflected there across the... it's in the course of drawing a peak of some sort or other.

Oh yes. And that's the little black thing we can see on the paper, it's moved across from the left.

That's right, yes. Yes that's right, yes. And, it's all pretty straightforward stuff. It was an incredibly simple piece of equipment. And my other colleagues from the other science departments, including one from Germany who was measuring carbon monoxide, and had a whole lab full of elaborate equipment to do it, could not believe that this simple bit of gear was detecting things at impossibly dilute levels, parts per trillion. Among the things it detected, which I haven't mentioned, was the natural emission from the ocean of a compound methyl iodide, and that was present in some parts of the ocean at a level that, put in the air, no more than one part per trillion. Really going down the... but we could still detect it and measure it. And, there were other gases that were present, like carbon tetrachloride was in the air, that gave a peak, and, so on and so forth.

[02:09]
Do you remember the exact words used by the, the German scientist to express his disbelief about your equipment working?

It wasn't so much disbelief, it was more wonder.

Mm.

He was a nice lad. Because when he got back to Germany, his boss, who was a very distinguished German aeronomist, atmospheric chemist, called Professor Christian Junge, invited me immediately to come over to Germany and give an account of the *Shackleton* voyage. And, I got subsequently invited by him and them to make another trip on a ship, the *Meteor*, a German ship, from Hamburg to Santo Domingo, doing similar measurements.

Mm.

Which was great fun. Anyway, there we are, that's that.

[End of Track 7]

[Track 8]

That's quite interesting. It's very historical. This is a historical chromatogram, using very similar apparatus to the one that was taken on the *Shackleton*, almost home-made, on, taken on March the 1st 1972, and it's showing the analysis of outside air at Bowerchalke in Wiltshire, and there you see the peak for the chlorofluorocarbon-11, and there's the peak for carbon tetrachloride, and there's the one for oxygen of the air.

So the oxygen is on the right...

That's right.

...and the tetrachloride was on the far left. Yes.

And, that little negative peak there is the point at which the syringe injected the five cc's of air. You get a negative peak because it, it increases the pressure in the detector slightly, because you push it in quickly, just as a transient, and that increases the electron current a little bit. So... But, that rapidly dissipates and it becomes equilibrated, and then the run goes like that. And here it's showing you the areas by, we did it by triangulation in those days. Of course nowadays it's all automated, the computers do it all, you don't have to do the... But you very carefully draw on each peak lines that... And then, you measure the base width and the height where these two points intersect, and that gives you a very fair estimate of the area beneath that, that peak. And, since the deflection is the measure of current, and the movement horizontally is the measure of time, the integrated thing which that area indicates, is the number of coulombs, that's amperes per second, of that signal. It turns out that was 1.75 times ten to the minus nine, nano... It was one and, 1.75 nanocoulombs. And you can calculate that that corresponded to a quantity of, well in the case of this, this particular peak, of twenty-nine picograms of chlorofluorocarbon-11, twenty-nine trillionth of a gram.

Mm.

And you can see, the signal is very strong, it's well above the baseline, there's no sort of vagueness about it, it's very certain, very, very, quite accurate. [pause] On there, there's the current you see. One square on there is 2.6 times ten to the minus eleven amperes. That's the sensitivity of the thing. That's an awful small amount.

Mm.

Twenty-six picoamperes it's measuring.

And these are annotations that you've made on...

That's right.

...this, this recording data that's come out of the...

That's right, yes.

...the piece of equipment we're seeing.

Yes, you can do that. On the 1st of March.

So would that, 1972 there, would that have been before you were using a, a personal computer for calculations of this kind, or are these calculations so...?

Oh no, I was, by then I was, had a personal com... Well, you call it, you would hardly call it a computer, it was a calculator back, back then. But it, I had it on my desk, yes, and was using it for a lot of stuff. And that's, it was with that that I worked out how the ACD worked.

Mm.

[03:36]

Oh the only other thing perhaps which might be worth putting in to the British Library, the first of my significant I call home-made instruments was this, it was an ionisation anemometer.

Oh yes please. Yes, the air movement.

For, for the Common Cold Unit. When I was researching the common cold in the 1940s, this would be about 1947, one of the things I had to have, and everybody demanded that I have, was something that would measure draughts. Now draughts are air movements that are so slow that none of the available anemometers could measure them, even get near measuring them. So, as usual, what does one do, if you're an old-fashioned scientist like me? You have to invent an instrument that will measure draughts. And I thought about it a lot, and I invented two. One was to, an ultrasonic anemometer, which is now quite widely used everywhere, although, it was, I never patented it in those days. Didn't even think of patenting yet. This was a rather subtle instrument. You have a source of ultrasound at one point and a, two microphones, one on either side of it equidistant, and you compare the phase angle of sound waves arriving at each, each microphone, which is easy to do electronically. And, all the thing in the middle, the source, has to do is to emit sound continuously. And, if there's a wind blowing along the path, the phase angle of the arrival of the sound waves, because sound travels through the air by air motion, will be different from the phase angle at the other one.

Mm.

And, it, it makes a wonderful anemometer, because you can do it in any number of dimensions. You can have three microphones and this'll give you the vector of the sound, which direction it's going, as well as what its velocity is.

[05:40]
And so in the picture, the, the thing on the...

This is a different one.

Ah.

The trouble with the ultrasonic anemometer was, in those days, nobody had invented the ceramic producers and microphones for ultrasounds that are based on barium titanate and things like that. It was more old-fashioned stuff. And, it was very difficult to make a sound source that would give you ultrasonic sound of sufficient intensity, and it was very difficult to find microphones sensitive enough to pick it up. So, the whole apparatus become very cumbersome. It worked, but it was cumbersome. And I thought, oh there must be a better way of doing this, a simpler way. And it suddenly dawned on me that ions, that's positively charged molecules, or negatively charged molecules, travel through the air quite slowly in a weak electric field. So I had a source of radioactivity on here which was actually polonium, the stuff that they used to kill that unfortunate Russian agent in London, Litvinenko.

Mm.

And...

Is that the little sphere at the top?

That's the little sphere at the top.

How was it containing the radioactive material?

It was just coated, electroplated on it.

Right. I see.

Because it's a metal, polonium. And, that fired off alpha particles that had a range in air of about four centimetres, and that, that, the cage, the metal cage around it, the open cage, was more than four centimetres in diameter. So the ions were within that cage, and if there was no air movement, putting an electric potential between the, the rod in, the sphere in the middle, and the cage, you would collect the ions, in this case the positive ions we collected, and, that gave the signal. Now, if an air blew, wind

blew, some of those ions would get blown out of the cage, and this was the measure of the wind. It was so sensitive it could detect an air movement of a foot in a minute.

Gosh.

And, more than sensitive enough to detect draughts. So, it, that was it.

[07:51]
Where did you take that instrument, did you take that into the field in various places?

I took it very much into the field, because, I had, I love ships, as you will gather, and any excuse to go. And I was at a meeting of a Medical Research Council committee in London, even though quite a junior scientist at that time, that would be in, what, '46, so I'd be about, twenty-six. And, I was there. And, a representative from the Royal Naval Personnel Research Committee, he would have been a doctor, said, 'Oh I don't suppose any of you there are interested in coming on a six-months cruise on... sorry, six-weeks cruise on the aircraft carrier *Vengeance* into the Arctic next winter, in February?' And I said, 'You bet, I would love to go.' And, it turned out that they wanted... Habitability, that's... and air movement was one of the important things to measure for, for the comfort of the mess decks of the ship. And, so I took, carted my anemometer along with ne up into the Arctic on that, that voyage. And it was great fun. It worked like a dream, it worked very well. It had one big drawback though, it was sensitive to tobacco smoke, that upset the measurements quite a bit. And it was difficult to get the sailors to stop smoking [laughs] when you wanted to do a measurement.

Mm.

It... But that actually was what turned me on to inventing the other sort of detectors for the gas chromatograph when Archer Martin first suggested I should. I remembered how sensitive this one was, and how sensitive it was to other compounds like CFCs and tobacco smoke, and I thought, well maybe we can turn this into a sensitive chemical detector of some sort.

Mm.

And of course, that's how I did it.

Sorry.

It's very important to know that none of these inventions would now be possible, almost anywhere in the Western world.

Because of the...

So strong are the strictures set up by health and safety, and by the Green movement, against any form of radioactivity, that to actually get and build equipment like that in the lab would... the, the sheer cost of it and the restrictions on what you could use and what... would deter that kind of thing. 'Oh well let's have a go with this.' You... it, it would deter the proper application of science. It would all have to be handed out to a bunch of experts, the whole thing would be a major operation. Whereas for me to try that was not much more than an afternoon's work.

[10:40]
How... at that time, how were you able to procure the radioactive material that you needed?

I just phoned up Harwell, and got talking with one of the radio chemists there, and I said, 'Hey, what's the chance of you coating a sphere of one centimetre in diameter brass sphere with polonium so that I can use it as a radioactive source?' 'Oh,' he said, 'no, no trouble at all. When do you need it?' And I said, 'Well when can...?' He said, 'Oh you can have it tomorrow if you want. There's no... we can easily do that.' And it was all done between two government labs, without any paperwork, anything.

Mm. And how did, how did they deliver it to you?

In a box. [pause] They didn't even think then that polonium was dangerous. Because, being an alpha emitter only, doesn't emit anything else, the alpha radiation won't even penetrate your skin.

Mm.

So, you've got no immediate radiation hazard. And it's got a short half-life of about 130 days, so it's soon going to go away. And they were very happy to just send it to me through the post. Nobody at that time knew that if you ingest polonium it's one of the most deadly isotopes of the whole lot, but, that was then. [laughs]

[12:00]
And what about for the ECD, did you... the procurement for that, for...?

That was not quite so easy, but it was still, compared with now it was child's play. There was, there was a large firm formed, I think it was a government, a nationalised firm at first, called Radiochemical Industries, that lived at, operated from Amersham in Buckinghamshire I think it is. And, it was just a matter of, when I was at the National Institute for Medical Research, placing an order through the regular ordering system of the Institute, 'Could you supply me with a twenty millicurie source of strontium-90?' Which they did. And...

And how did that arrive?

That arrived in a little lead pot, in, in an approved container. I think quite often what they did was to put the pot inside, with lots of polystyrene protection, inside a tin can, which was then sealed in an ordinary tin can procedure, and then that was sent through the post. It was no radiation hazard, it was... and, there was no way people could get at it, except by opening the tin, which is not... And they didn't worry about things then. And that was that. And you were expected at Mill Hill to be, as a qualified scientist, to know all that was necessary to know to protect yourself and your colleagues against any radiation that you worked with. That's utterly impossible now, it has to be all done by approved health physics officers and this kind of thing.

Mm.

And it deters any simple inventive production. I think it's a dreadful hang-up of science, and all done, introduced by Green ideology. Not by... Because there was no real dangers involved.

Mm.

[End of Track 8]

[Track 9]

Could I ask you first of all in this section whether for any of your work you've been asked to sign the Official Secrets Act?

Oh yes, but only relatively, how can I say, in the middle of my research career. During the war, it was funny, we were doing all kinds of secret research and things, but nobody seemed to worry about security much in those days and I don't remember signing anything. The National Institute for example, that had the most dangerous things in it, like scrub typhus virus, that was almost universally lethal, [laughs] and would be locked up in a containment facility nowadays with guards of all kinds around, that was just in a lab in, in the refrigerators and things like that. And anybody could walk in, there was no guards of any kind. And that was during wartime.

Yes.

Things have changed enormously. And I think it is partly a consequence of the change in our status as a nation. We were so secure and confident of ourselves in those old days that we didn't worry about security much at all. I think it was the American experience that, and the influence of America when it became the lead world power. People tend to forget, we were the lead power before that and were running our own rules. Their rules were much more paranoid in many ways by our standards, but they became enforced here. And that led to a lot of changes.
[01:41]
So security didn't really come to me until the... I can remember it very clearly. I'd been in America, and, got involved with the CIA and various other security organisations in America about the possibility of tracing people by using electron capture, that's to say, labelling a person with an electron capture emitting volatile compound, a smell if you like, an electron capture smell, but would be odourless, harmless, but enable them to be detected at, from some considerable distance, using an ECD. I couldn't persuade the Americans, they didn't believe it. I think they were so used to contractors coming along: remember I was working on my own then and was therefore classed as a contractor, coming along with exaggerated, absolutely fantastic notions of what could be done with their gadgetry, that they just could not

believe something that really did work at that level. So I didn't get very far. But when I got back to Britain, one of my customers in Britain was the Shell oil company, and, my contact there was Lord Rothschild, who was director of research, coordinator I think they called it, of scientific research for them, and he and I, you know, established quite a friendly relationship. And, I told him of my, [laughs] tale in America, this security problem that had arose, and I said, 'I was beginning to get a little worried because perhaps, I shouldn't have been giving a foreign country the advantage of an idea that, that could be even more helpful to us.' And he said, 'Quite right that you came to me.' He said, 'Leave it to me, I'll, I'll get in touch with our people here, and, you'll probably hear from them shortly.' And sure enough, within a couple of days I had a letter, I don't know where it came from, from some civil servants, I think they called themselves Ministry of Defence even in those days, I've still got the letter somewhere, asking if they could come down and see me at Bowerchalke and discuss a problem they had got. And three of them turned up. And, we had a very pleasant afternoon. And their hypothetical problem was that, they wanted to label either camels or camel riders crossing a desert, because they suspected that arms were being smuggled across from one part of Arabia to another, and that this was, you know, one of these military security problems, and if they could use one of these agents to, to check which camel passing some point in the chain was the one that was labelled, it would be very helpful to them. It all made sense to me. And, they said, 'Do you think your thing could do it?' And I said, did a few sums, I said, 'Oh yes, it could easily be done. But you'd need detectors on both sides of the trail, because you...' depending which the wind was blowing. It's a, it's a smell in effect, and it's like a dog, if he's on the, sort of upwind of what the source is, you're not going to pick it up. Apart from that constraint, if you have two of them, one on either side trail, yes, it can be done, and done very well.

[05:20]

And, before long, I was called up to Century House as it was then, MI6 headquarters in London, and asked to give a lecture on it to them, to quite a big audience. I was surprised how big it was. And it turned out subsequently that most of the audience were not MI6 but MI5. The, this kind of warfare between those two services is legendary, in fact they worked together quite well; I'm sure individuals quarrel as they do any time. Anyway, that was it. And one member of the audience, a civil servant called [05:57 - name removed at interviewee's request], who became a

lifelong friend, still is a friend, sadly he's retired now, and getting, like me, pretty old, asked some very pertinent questions, really crucial questions, good... I mean, I was dealing, not with just spooks or, or civil servants; I was dealing here with a really good scientist, and he knew his job. And, I loved it, I love people who are really professional and thorough. And before long, I went over to his unit, which was part of MI5, and, their headquarters were in Leconfield House in Curzon Street in those days, but they actually worked in places dotted all over Mayfair, in sort of, private houses and God knows what.
[06:58]
And anyway, we soon got down to brass tacks and I had to do a demo of the, the thing, in the New Forest. And, that, that satisfied them that it really worked.

Could you describe that demonstration in the New Forest?

Yes, it was really, one of their people, I've forgotten his name, sat with the apparatus that I had made, this sort of home-made sensor, electron capture sensor, at one plate position, and I shot off across to the other side of the forest, but, upwind of him, and released some sulphur hexafluoride gas into the air, a harmless gas, which is strongly electron capturing, and did it at a number of intervals over a period of time, taking careful note of the time. And he was also taking careful note, and, sure enough he got the three signals the three times in, in question. So they were then satisfied the thing really did work, and it worked at distances.
[08:09]
And, it, it subsequently got used by NOAA in America, the National Oceanic and... Administration, a kind of ground-based NASA, not too well known about but very important agency. They used it on a grand scale to label air in California, to simulate a, a large nuclear release, or a hydrogen bomb explosion like that. And then followed the labelled mass, labelled with, in this case, a pure perfluorocarbon that was harmless to the ozone layer, all the way across America to the east coast, and got a measure of the distribution mixing of the air and what would happen in real life. It was quite useful. We could have even picked it up here in Britain if we had wanted to, but nobody was interested in doing it.

When were they doing that, the NOAA?

That would be in the 1970s I think.

And was that because of concerns about fall... was it simulating fallout, the movement of...?

It, it was actual... All it simulated was the air movement. You would have to work out what the fallout would be.

Mm.

Because the gases used were completely inert gases and they would move with the air. They wouldn't fall out.

Mm.

But it was, yes, you're, you're right in a sense, they wanted to know where the stuff would go.

[09:35]
Thank you. The New Forest test, what is the significance of the forest in terms of the test?

Nothing really. The New Forest is just a place, it's heathland, there's not all that much woodland there. But it is an area of parkland. I don't know whether it was National Trust or what it was in those days. It was possible to do an experiment like that, which was unscheduled, nobody knew about and you didn't really have, have to ask permission. Perhaps we should have asked permission of somebody, but, we weren't harming anything, it was...

And how far away from...

And that was quite close to Bowerchalke, my lab, you see.

Mm.

That was the other factor.

I see. And how far away from the chap with the recorder were you? Could you see him, or was it much further away?

I can't remember now, but I would think it was miles.

[10:27]
Ah, OK. Thank you. And the detector that you made for this person to demonstrate that this would work as a way of labelling...

Mm.

How different was that from the electron capture detector...

Oh it was an electron capture... It was more the set-up, how do you collect the air sample? Because you can't go [laughs] taking syringes and drawing up air; you need a continuous type of thing that was what we called real time sampling. And there were many different ways of doing that. The way we did it ultimately was to draw in air through, mix it with a certain amount of hydrogen, draw it through a palladium, heated palladium tube that was heated to, I suppose about 200 Celsius, just a thin, narrow, bit of pipe really, and the palladium completely reacts with the oxygen in the air with the hydrogen, so that it, it all vanished and you've got the, the fluorocarbon vapour which is unaffected by the, by the hydrogen or anything else, or the palladium, passes on just in nitrogen. But it's rather wet so the next step is, you pass it through a peculiar material called Nafion. That's a tube. And that is very permeable to water, so it lets all the water vapour out, and then you are left with just nothing but nitrogen and your added gas, the fluorocarbon. And that went straight into an ECD. And with that you could detect parts per trillion of the perfluorocarbon released somewhere. It was what's called a real time sampling.

[12:12]

And do you know whether, having demonstrated that this worked in the New Forest, do you know whether it was used as they wanted, to label camels and riders move...?

Oh heavens no. That was just the cover story. The real, their real interest was tracing the KGB, who were in those days very active in London. Their embassy and their trade centre in Highgate, they had all sorts of people, who, some of whom our, our authorities like MI5 knew were illegal, they were agents, but they didn't expel them because they were concerned with where they travelled and things like that. And, this is where we came in. There were various ways that you could, which I can't go into, you could plant on their cars or their persons an emitter of this perfluorocarbon gas, and, and have detectors. The detectors were set up on the bridges...

Ah.

...across London, so that you could tell where they were going and what their, their directions were.

Now, obviously don't say anything that, I know that you won't say anything that you're not allowed to say under the Act and that sort of thing, but, how would... I'm just interested in the pieces of equipment. How would the, if they were installed on bridges, would they have to have someone near to those...

No they were automatic.

And so, how would the signal get back to base or, or wherever it was going? Would it...

[13:46]
Well... Hold it a moment. Much of what was done was in, of an experimental nature, and, scientists from the organisation would, could be used to conduct the experiment. In fact, I was set up then, in that, almost as an employee of theirs, although I wanted to retain my independence, which I did as an independent scientist. They set up a laboratory at Holton Heath in Dorset, which is part of the, in those days was, it was originally the Admiralty Materials Laboratory, but it became, typically in the post-war

absurdities, the Ministry of Defence Ship Departments Materials Laboratory. But it was the same place. And that unit had gradually expanded. And it still exists, it's now at Porton Down.

Mm.

And... But by the Nineties, early... Was it...? Yes, no, by the 1990s, it was a big secure establishment at Winfrith in Dorset, and, led by a friend of mine, a civil servant called [15:01 - name removed at interviewee's request]. And, oh it was, you know, quite a, quite a thing, and quite a source of pride to me to have founded a, a group that large. It dealt with, from there, not just with that particular problem, but all sorts of problems in all sorts of fields that I can't go into, it became a kind of, broad science investigative centre for methods of detection, tracing, all sorts, for the security services.

Did it only focus on tracing and detection?

No, it... all sorts of problems we had.

[15:45]
And, how would you summarise your work with the security services from then on until the present?

Well, I was very active during the, that period, in the late Sixties and early Seventies, in establishing this laboratory at Holton Heath. But once it got established, it became a regular Civil Service department and I was just then no more than a consultant to them. And gradually that role dropped down to a relatively minor one. But, I've kept contact with them ever since, and still am in touch with them, and working on...

Presumably you're not free to talk about work that you're doing for them now or...?

Oh no.

[16:32]

No. Are you able to say anything about your work in relation to the Northern Irish situation and your work with security services?

Well for obvious reasons, the Northern Irish war, if you can call it a war, was very active from about 1970 was it? When was Bloody Sunday? I've forgotten the time, it was round about then.

We are involved... Yes, we're talking about the Seventies I think, yes.

Yeah. It was from then right until the peace process.

Mm.

And it still reverberates around, you've got rather mad fanatic groups that are still active. But, in its heyday, when it was a, a pretty active movement and carrying out almost a, a war in, in Belfast, it was very much the concern, because, as you well now there were numerous attempts, some of them successful, at planting bombs in London and other parts of Britain. And, so yes, it was very much our concern. And we did an awful lot in that, that affair. Which was odd for me, because, I was simultaneously running this monitoring station in Southern Ireland at Adrigole, measuring this, the, gases in the atmosphere, the, the pollution gases and things like that, rather than, tracer gases.

Was there any link between your, your position there and your work with the security services?

As far as I know, nobody in Ireland had the slightest idea that I was linked with the... In fact, my life would have been at risk had they done. I would have been a legitimate target.

[18:15]
And when you say in your autobiography that you feel you've, you've done something to counteract terrorism...

Mhm.

...that is in relation to the Northern Irish...?

Oh not that alone. No, it applies to all forms of terrorism.

And, again, obviously you can't go into detail, but, is, is tracing, is labelling and detecting and tracing and tracking, is that the sort of work that you, you advise on and you're, you're concerned with, or has it gone beyond...?

Well as you probably gathered from my life, I'm somewhat of a polymath. I feel at home in almost all branches of science, from molecular biology going down to hands-on biology, bacteriology, medicine, even to a small extent, animals, plants, right the way through to chemistry and all branches of it, and, and physics. So, problems obviously. Often, the interesting things are at the border between disciplines. The people in the disciplines of science are amazingly illiterate about the, the scientists in other branches. It's, it's got so bad, I think there's no less than thirty different branches of biology, and they react almost as if they were proud they know nothing about the other branches.

Mm.

And, I mean I can give you a simple example. If you picked up a wild flower in a field and took it to a typical university nowadays and asked if you could, asked to see the professor of biology, and you went to see him and said, 'I wonder if you could tell me what this flower is?' he would say, 'Oh yes, how interesting. Well I wish I knew, but you will have to go and see the botanist, the professor of botany, he's down that corridor over there.' So you go along to the botanist and he'll say, 'Oh yes, I'm sure I know that but, you know, it, it's not really my field, this. You ought to go and see Bert so-and-so down there, he's the reader in cryptogamic botany, and I think it might be a cryptogam of some kind.' And so on.

Mm.

It's just that, common knowledge is no longer there.

Are you...

It's, it's divided into expertises.

Is the implication then that you, you're being asked by the security services to work across all kinds of science?

I, I tried that very hard, and it, nowadays it's reached... these, the group that do them, did the work at Winfrith and still do it at Porton, cover almost all fields, yes.

[21:05]
Have you been asked to use your science to help the security services in any way that you've been uncomfortable with?

Not so far.

Mm.

No. Almost the reverse. One of the first astonishments I had about the security services, when we were talking of using these agents, the pure perfluorocarbons, they are compounds that are so non-toxic that they are used by the Japanese as blood substitutes to, to, the people who have got very serious anaemia or lost a lot of blood, you can inject them with an emulsion, so that, thirty per cent of their blood is replaced with perfluorocarbon. And this carries the oxygen nearly as well as the haemoglobin.

Mm.

They're that non-toxic. And if you fell in, theoretically, in a vat of pure perfluorocarbon, and it filled your lungs, you wouldn't drown, because it carries oxygen as well as air, and you could go on breathing. It would be a bit heavy work [laughs] breathing the liquid in and out, but, they've done it with animals and it doesn't kill them. So, you couldn't find... In many ways, it's less toxic than water,

because you couldn't fall in a vat of water and fill your lungs without, [laughs] without dying.

Yes.

So, when they asked me, 'Are you sure this is safe, to use it as an agent? We don't want to poison these KGB agents, we don't want to be found, seen to have poisoned them,' I was astonished. I would have thought that that, that would have been the least of their worries or fears. And that was the attitude generally, that you don't ever use things that might be harmful to people.

[22:47]
Apart from then that, you being surprised about that sort of benign concern with the...

The enemy.

...with the enemy really, yes, in what other ways did your actual experience of the real security services differ from your impression of them gained from, as I know, reading spy fiction and that sort of thing, before you became involved, in what other ways were they surprising?

Well, you have to be limited here. I was not involved in operational activity directly, ever. It doesn't mean to say that I haven't met quite a few people who **were** involved in operational activity, but I can't really judge how they would react in... As I say, it's right outside my remit, and I know nothing about them. But the people who became close friends of mine, I found to be exceedingly honourable, decent folk, you know, worth having in any society. They were not the kind of thuggish characters that, that silly fiction tries to portray them as, they're not like that. And I think good professionals everywhere are fairly decent people. Of course you get bad eggs amongst any group, doesn't matter what they are.

Mm.

[24:06]

And... But no, it was a constant surprise. And it was rather similar to the surprise I had in industry. I remember early in my days working as an adviser to Shell, I attended the meeting that Rothschild sent me to, and the subject for discussion was the production of lubricating oils for cars that would last the lifetime of the car. [laughs] And I looked kind of puzzled, [laughs] and I said at the meeting, 'Surely this isn't in the interests of the company. Don't you want to have a constant supply of oil for replacement and all the...?' And they sort of looked utterly shocked. 'Oh no no no, you don't understand. We want to improve things. Our research objective is not, not a sort of planned obsolescence, that's just a fictional idea. We don't go in for that at all. We know that if we can produce an oil that will last the lifetime of a car, it'll out-sell all the, all our competitors.'

Mm.

It was, it was, there's a kind of enlightened self-interest in these things which so often fiction and the student Left have characterised as wicked, evil and all the rest of it. Which is nice and convenient for them in a tribal sort of way, they're the baddies, we're the goodies.

Mm.

But in reality, it doesn't work out like that. But again, I don't want to appear naïve here. I'm sure there are bad types and bad ind... I mean in fact I know there are some bad industries that behave exceedingly badly, to their workforce and others, but they're not the, the rule.

[25:48]
Mm. Thank you. Now, in your book you mention that, the very first sort of contact between the CIA and you originated with Sandy Lipsky at Yale...

That's right.

...who had been asked if there was any way of finding people hiding in dense tropical forests.

That's right.

Was that in the same way as the... I mean, I was fooled by the camel story, even now. Was that a cover for a different interest, or were, was that a real interest in...?

I never know. I don't know. I suspect it was less a cover and it was just a way... That was at the height of the Vietnam War, and that was the obvious American interest, and, certainly they were anxious to pick up groups of Vietcong in, in jungle, they would have been glad of any way of doing it.

And you said that you did some calculations to see whether the ECD could be used for that purpose.

That's right.

What did doing those calculations involve?

Well, if you could, for example, put so much of a detectable agent into the rice, if you could get at the, nobble the supply of rice going to... and it was ingested, they would be breathing it out, and where there was a group of them, in some point in the jungle, if you flew over in a helicopter you could almost certainly pick up the, the ECD signal.

[27:17]
And you, you had that, you had those calculations. I wonder whether you could tell the story of meeting the CIA members behind an antique shop?

Yes.

So presumably you were taking along this idea of the rice labelling to that place?

Sure. No, I talked with the character... Class... I realise now that, they may have been CIA, but they were like the people in our MoD. They were typical civil servant

scientists, and, one got so kind of befuddled with the fictional side of CIA, agencies like that. The truth is always so very different. These were just ordinary guys, chemists like myself. But, as I said earlier, one of the flaws in America is hyperbole. I found out the hard way, that it always paid, if I was trying to advocate an instrument like the ECD, to under-sell it by, shall we say, a factor of ten. I always said it could just about detect a picogram. In fact of course it can detect about 100 times less than that. But, every, a typical American going along would have said, 'Oh no, it can detect a, you know, thousandth of a picogram.' Exaggerating. Of going beyond this thing. So, they, when I told them the truth, or slightly under the truth, they just thought that was an exaggeration, so they dropped a factor of 1,000. And it wasn't any more sensitive than the general detectors they'd got available, so they weren't going to believe it.

Mm.

It's another bullshit artist trying to [laughs] snow them with a, a fanciful instrument that didn't work.

[29:08]
And so you sensed that they didn't go for it at that time.

That's right.

But you mention that they, that you are aware that they used it many years later?

I don't know. I've no knowledge of that.

Mm.

I'm not privy to what they are up to.

Mm.

[End of Track 9]

[Track 10]

Could I ask you what the link was between your instrument, your object, the electron capture detector, and Silent Spring?

Initially no link at all. If you read Rachel Carson's book *Silent Spring*, it's a very interesting, very powerfully written book. She was a wonderful writer, and a true old-fashioned naturalist, and she really cared about the natural world. And, it was to show how broad she was on that, her book, *The Sea Around Us*, gives some wonderful descriptions of the coastline and rough seas around Britain, which is far from her native America.

Mm.

And... And *Silent Spring* was primarily a naturalist book that was concerned about the loss of birdlife caused by the injudicious use of pesticides in farmers' fields. And, she tried to make her case very well. The evidence she gathered was from chemical analyses of the amount of pesticide in, in the stuff that farmers sprayed on fields and put in, into grain and things like that to, to stop them going sour, and, and, chemical analyses of dead birds and dead animals, and attributing their deaths to their imbibing the pesticides that had been spread around. It was a good attempt to make a causal link between the spraying of pesticides and the death of birds. She, I mean, went a little bit over the top with the title of *Silent Spring*, indicating they were all dead; it sort of, it didn't allow for natural response of [laughs] people sort of, noticing bad things happening.
[02:07]
But anyway, leaving all that aside, it was pretty good. Now, the reaction of the pesticide makers, and there by an amazing coincidence, I was deep in it, because, Shell, who, with my contact, Rothschild, who was a biologist incidentally, and a fellow of the Royal Society, no, no kind of, non-scientist, were quite deeply concerned when Rachel Carson's book came out, because it affected their industry quite, enormously, because they were makers of dieldrin and DDT and those other things. Rothschild's first reaction was anger at the way Rachel Carson went right over the top, and anger at the use of very dubious chemical analysis procedures to sort

of lay the, the finger of blame on the industry. And, it was quite extraordinary, because, on the very day that I went up to see him in London about this, and he, he was full of comments on Rachel Carson's stuff, I had received two letters, one was from analysts employed by Shell at their laboratory at Sittingbourne in Kent, who had used my ECD, they had actually come to Mill Hill to pick up an early version of it, to analyse pesticides, and their report confirmed everything that Rachel Carson had said. And the other letter was from the EPA in America, that also had, their scientists had made an ECD and confirmed the whole of Rachel Carson's story. [laughs] So, I was able to say to Victor Rothschild, 'Hold it a minute, I'm afraid I've bad news.' And told him about that. And he was, he was very much set back. And it wasn't long before Shell stopped producing it, quite voluntarily, they didn't have to accept a ban.

[04:15]
Was there any link between Shell and the Monks Wood experimental station? I know that there government scientist called Norman Moore.

No that was... I think Monks Wood was a government lab, wasn't it?

Mm.

Yah.

I know that he was working on the thinning of bird eggs for example, and...

Oh yes.

I don't know whether, I don't know whether there was any sort of, formal link between Shell and... It was a nature conservancy... Yes.

I've no idea. I've no, I've no idea. I didn't come across that.

[04:44]
Thank you. Now, I'd like to ask you a general question which has been prompted by things that I've read of yours, and also sort of, things that you've said to me over the

course of the last couple of days, and, I wonder whether you could comment on your view, broadly, of the 1960s as a decade. Because you've mentioned feeling that some aspects of social and cultural change in the 1960s were negative. And, the reason I'm asking that now is that, Rachel Carson in some ways represents a change from a, a culture of natural history in Britain which was centred on the amateur, but had aspects of the modern, and we might see the New Naturalist series of books as sort of almost summarising that, that, field ecology, but a kind of modern attitude to things, a modern, an acceptance of the, of modern developments, was part of that, and that Silent Spring is sometimes seen as marking a change, a kind of, explosion of Green environmentalism which has taken it away from the field in some ways. But I wondered whether you could comment, not just on that but on your view of the 1960s in general as a period of social and cultural change and its influence on your work.

[hesitates] Yes, that's a tricky one. You mention the New Naturalist series. That was a great favourite of mine, in fact I think I've got almost all of the books they published, those green volumes.

I suspected you might have, yes.

Yes. Orchids of the chalk hills and limestone by J E Lousley, whose family were probably the employers of my grandfather's father.

Ah. Mm.

Because they were in the brick industry. And, another coincidence. His name, J E L, J E Lousley's not the same...

Mm.

But... Yes, but one of those books was *Pesticides and Pollution* by Mellanby. So perhaps, does that break the thing, or did that come after the Sixties? I've forgotten. I've got a copy, so, naturally I have...

They were published, you know, from, throughout the post-war period and...

That's right.

...and onwards, weren't they, so...

It might have been post-Sixties.

Mm.

[07:07]
OK. Well we'll not hold that out as an exception at the moment. But it did happen. Yes. I'd really have to think a bit about this, because, let me see, the Sixties... The first three years of it, I was in America, in Texas, so I didn't much see it, things were not changing very fast there at that time. I came back to Britain and there was an enormous difference in Britain between the time I had left and the time I got back, and, I went to Bowerchalke of course to live when I came back in January 1964. And, it wasn't long before the village environment of Bowerchalke began to change adversely with the introduction of agribusiness, which gradually became widespread in southern England and, there were all sorts of social changes that were never ever noticed. I mean I'll give you one example which made me very mad, was that the village communities across southern England were wiped out, quite literally wiped out. I mean, the village of Bowerchalke had everything. I think I was telling you, you mentioned this yesterday. But among the things it had for example was the village cricket team and its own grounds. And it was a cricket team good enough to beat the county of Somerset, [laughs] which gives you an idea of their quality. And there was a wonderful community spirit in the whole of the village, in all sorts of ways, and it was a complete unit. It's now largely an exurb of wealthy retired people, very gentrified. There's not a single country person to speak of left of the old, old ones that I knew, and yet in the early Sixties, before the change, it was all, almost entirely. There was, to be sure, I was living there, as an outsider, and so was Bill Golding, but we were different, in that, we sent our children to the village school. We were not sort of, the typical middle-class outsiders that just use the village as a place to commute to and from, not a, not a part of it. We were very much a part of it. I was, for example was on the parish council for a period, [laughs] a job I found was

not very satisfying, but I was. And that, Bowerchalke was just one of huge numbers of villages.

[09:50]

Now there was an enormous concern about the destruction of the mining communities a generation perhaps later, great sympathy for them. No sympathy at all for the country folk.

Mm. Mm. Mm.

Who were driven from an idyllic existence in the countryside into council houses in Salisbury, and places around. [pause] I mean that, that story is widespread, it's manifest everywhere.

Mm.

And I think one of the criticisms I have, and this, I'm not saying this in a political sense, of the socialist governments, is that they're mainly urban, and they have no understanding or feeling whatever with the countryside, and they don't think in terms of the people living in villages as like miners who are industrial workers and therefore especially of their, part of their, their set-up. [phone ringing] Don't take any notice of that.

[pause in recording]

[10:52]

That can easily be dealt with, can't it?

Yes. [pause] Thank you. Could you... We'll come back I think to the 1960s when we talk about Gaia and we talk about relations with the Green movement.

Mhm.

[11:08]

But, I'd like to tackle the, your involvement in ozone, the ozone...

Sure.

...what became the ozone war.

Mm.

And, could you start by describing in as much detail as you can the origin and practice of what you say became a family ritual of measuring haze at Pixie Cottage in Bowerchalke.

Yes.

Including your daughter's involvement, the pieces of equipment used, how often, all of that.

Yes. [pause] Let me see. I, I did mention some of this yesterday, didn't I?

Yes.

Yes. It... Well its roots go right back to childhood and memories of the great distances one can see in the countryside, how clean the air was, how, compared with how filthy the air was in London. What we seem to have done as we went into the century was, diluted the pollution in, in the big cities, [laughs] and spread it out all over the countryside, you could, you could summarise it as.

Mm.

And it was far less toxic if it was spread everywhere. But it was aesthetically a lot less pleasant.

Mm.

Indeed, I would go even as far as to say that the pea-soup smogs had a certain romantic aesthetic quality about them, even though they were quite lethal. Whereas the haze has nothing to recommend it at all in, in almost any direction, but it's fairly harmless. Right. Well, being a country person and involved, interested in these things, and an instrument maker, always when I see a thing like haze or something, oh I want to do something about it, to measure it, find out where it's coming from, and so on and so forth. It's the way old-fashioned scientists work.
[13:09]
And it, it just happened that, in those days I was travelling frequently to the Jet Propulsion Laboratories in California to work on, mainly on problems connected with the Viking mission to Mars that landed there in 1976 I think it was. Incidentally, there's two bits of my hardware sitting on Mars that was part of that, and that's why, part of the reason I kept going over there. And, on the way back from JPL, I almost always stopped at the National Center for Atmospheric Research, which was a great big American centre for atmospheric research, hence the name. I had several friends and colleagues there. And I got to now the director of those days, William Kellogg, quite well, and, we always had a joke, I would come along to him, because it's mainly, a bit like any of the great climate centres like the Hadley Centre here, similar sort of lab, I'd say, 'When are you going to open a department of biology here?' and we would laugh about this, and... Because it seemed so remote in those days, that I was feeling that since the whole atmosphere is biological, virtually, apart from the rare gases, that it was very, most anomalous to have a national centre for atmospheric research that didn't include the biology as well.

Mm.

But of course, that was not the way science is done. It likes to do separated things.

Mm.

And, meteorologists are not trained to think in biological terms at all. So, that's, they got interested in my haze story, and provided me with a simple instrument, a sun photometer, that I and my family used daily to measure the haze density in the air. And it was surprisingly high in the spring and summer of Britain. The haze density in

Bowerchalke, 120 miles from London, was the same as San Bernardino in, the smog sort of, centre of LA.

[15:23]
How did it measure, the haze, the piece of equipment?

It was an exceedingly simple device. It had a photocell at one end, and a means of colomating a little, it was a little wooden box, so that when it was pointed against, to the Sun, and the Sun was shining straight through, onto the photocell, you could see a needle on a meter. It reached its maximum. And also, just to help you, there was a little image of the Sun thrown on, through a kind of sighting device, so that you knew that it was at that, that end. And a protracted scale which, so that you could measure the trigonometrical angle that it was sighted at. It was a fairly easy instrument to use. And you sighted it at the Sun, and then you turned a kind of, switch at the side, and it switched between one filter and another, so, it was looking, the photocell was looking at the Sun through two different, two different solar wavelengths. And, this, this combined reading gave you a measure of the aerosol content of the atmosphere between you and the Sun.

And would it give you that as a number or as a, a line on a piece...?

No, it gave you two readings on the dial, which you then had to write down, and, then, either send the whole darn lot in to NOAA, they did the, with their system, somebody or other entered it in and calculated, or you could do some calculations yourself with those, with the numbers.

Did you do those calculations at...?

Yes, sure, I did. But I didn't do it routinely, because it was easier just to send the whole lot in to them.

And how often...

We were a part of the network of monitoring stations.

Mm. And there were other, other places around the world...?

Oh all round the world.

Mm. So the NO... sorry, the, NCAR, the Center for Atmospheric Research in America...

That's right.

...had already handed out these photometers to various other places around the world?

Not a lot, I wouldn't think there were more than about a dozen at the most, but...

Ah.

And around America, yes.

[17:43]
And your daughter's involvement in this particular problem?

Well, our family was always, we talked together, walked together and things like that, and, they were always interested in what I was up to. They weren't sort of scientifically interested, but they were interested in a general sort of way. I mean, they love doom stories, and, I remember coming back from JPL, and there was one nutty astronomer, was making a great big fuss in the canteen there one day about how in, I think it was two weeks' time, a comet was due to splash into the Sun, and, this might produce, you know, some amazing visual sights and things. And, people started wondering whether it might even adversely affect the Earth, you know, cause a, a solar outpouring that would upset the magnetic field and God knows what. Anyway, on the day that this was due to occur, and it was going to occur just before dawn, I dragged my whole family out, we got up at six o'clock and drove to the top of Win Green which is the highest hill near us in, in Bowerchalke, and, [laughs] it turned

out it was mist everywhere, we couldn't see a damn thing. But, it was a good try. And it shows the degree to which they were all kind of tied into that thing. Christine loved it, she loves that kind of story. And... So, it wasn't surprising that when I got on about this haze and how it came from Europe probably, and, whatnot, that they were willing helpers, put it that way.

[19:32]
And how often would... Presumably when you were away, or perhaps when you were there, Christine would take the measurements.

Sure.

How often would she do that? Once a day?

Oh, it was a routine more or less. Yes. It wasn't very onerous.

Mm.

And you only had to do it when the sun was shining.

Right.

So you missed quite a few days.

[19:50]
Thank you. Anyone else in the family involved in haze measuring?

Well Helen would do the measurements sometimes, when Christine... But Christine took over and sort of, she felt it was her, you know, it was her interest to do it.

And would she calculate the measurements, or would she send them into the atmospheric research place?

She entered the forms that were sent in quite diligently. I've got some of them around, some of the things they can archive.

And... Oh, I see, yes. And they were posted off to, back to...?

Oh copies of them were posted off, yes.

[20:28]
Thank you. Now this measuring of the haze I gather developed. And I wondered whether you could expand on the practice which you say was installed from the late Sixties onwards at Bowerchalke of measuring not only haze but also wind direction and CFC-11. Could you, could you sort of explain the development of the atmospheric measurements at Bowerchalke...

Sure.

...from the early haze measurements, becoming a little bit more detailed.

Well, the haze measurements became so interesting to me, because, at times at Bowerchalke, the visibility dropped down towards about a few hundred yards. I mean it really was bad in the summer.

Mm.

And it smelt funny, it smelt, got a vague smell of smog to it, the kind of thing you know if you've been in Los Angeles. And...

I, I haven't been. Could you explain what that smell is like?

I couldn't. No, you can't really. It's, it's... You recognise it as, as a smell. And... When it's strong as it can be in Los Angeles at times, there's a sense of irritation, your eyes start to water and... It, it's complex, because what you're smelling quite often is ozone, which does have a fairly strong smell. And... But also, ozone appears whenever there's a cold front passes. I think most people are not aware that with a

deep cold front passing across, the stratosphere comes right down to Earth's level, at the front, and that's when you get a burst of ozone from up in the ozone layer. And, since it's clear, clean air behind the front, you notice the difference between them, the two sets of smells, and you associate that. So that confuses the issue a bit. But the haze from Europe just had this kind of... I say Europe because we found out later that's where it came from.

[22:39]

But anyway, we were doing the haze measurements first, and wondering, pondering where it was, and arguing about it at NCAR, and, then I thought, oh, to hell with it. If I measure the CFCs as well, then that will tell me unequivocally that it's coming from some urban source, not too far away. And, that's what set me measuring the CFCs. I knew that I could do it, I had the ECD for other purposes, and, the notion of using them for measuring the CFCs in the air was easy, and so I set up to do it, simultaneously with the haze measurements. And it didn't take long before I found that whenever it was hazy, the CFC levels were much higher, about three times higher, than they were when it was not hazy. So that immediately meant the haze was urban.

[23:36]

And could you... To what extent was Pixie Cottage, the actual position of it, the, the geography...

It wasn't Pixies, Clovers Cottage.

Oh Clover, sorry.

[laughs] We had moved to another cottage by this...

To... And Clovers Cottage is the one that is at the top of the village, is that right?

No, it's, it was opposite the pub, more or less, Clovers Cottage.

And it's Clovers Cottage where your daughter was measuring the haze early on as well?

Outside it, but, I should say, Clovers Cottage was my lab in those days.

Yes.

It was, wasn't occupied. And for quite a few years I used it as a lab, and lived in the house in, in the same garden but above it. What happened was, we wanted to build a house in Bowerchalke when we were in America, and we bought this piece of land which had a cottage on it. It was quite cheap in those days, the land, which was nearly a, what would it have been, half an acre or something like that, and the house, was £2,000. [laughs] Different days.

Mm, gosh, yes.

And, then we had the house built on the other half of the land, but the cottage was kept as well.

And, the house was on the land, that was where the family lived...

Yup.

...and the cottage became the laboratory?

The lab. Mhm.

[24:53]
So, was there something particular about Bowerchalke or that part of England or the position of your particular laboratory or house that was important in making these measurements, the position?

No. No, it just happened to be, we lived there.

It could have been done anywhere in Britain, your measurements?

Well not in an urban region. It would have been confusing then, because you wouldn't have known whether it was... If you did it in a London suburb, you would be less sure that it wasn't local.

[25:22]
Yes. Thank you. And could you explain the practice of measuring CFCs from your laboratory in Bowerchalke, the particular set-up of the equipment, where it was, how often you did it, how you recorded, that sort of thing? What I'm imagining, for example, at the moment, is your daughter standing outside the laboratory, pointing the photometer at the Sun.

Yah.

That takes that measurement. And then I know that you live there, I know you've got this laboratory there, but I can't imagine you at the moment actually physically making the CFC measurements, because, I'm not familiar with it. I mean were you in the garden, up a tree...

No.

Where... You know. So how...

The same as on the *Shackleton*. I went outside. I didn't... I wasn't so spastic I felt I had to go and stand next to my daughter while she was doing the thing, but, it was in the same garden. The haze was covering hundreds of square miles, it wasn't just in, local like that. So I took... outside in the garden, away from the house, of course, it's no use measuring CFCs in the house, a refrigerator might have been leaking just so very slightly, you could, it was would alter the amount. And, took it outside. And, then took the syringe back in the lab and analysed it. That was the technique I used on the *Shackleton*. And indeed that chromatograph I showed you, March the something or other...

Yeah, 1972.

...was taken exactly that way, that was the kind of result I got from going outside and measuring it.

And that would have been exactly, that would have been at that place wouldn't it.

Yes.

Because you didn't move...

It was the same place, yes. Did that.

[27:05]
Now we know that the next step is your voyage on the Shackleton where you measured CFCs and air samples by taking air samples out of the, the sort of, porthole in the side which you've shown me on the photograph of the ship that we've got, and, I know that you found in the Southern Hemisphere forty parts per trillion, and in...

That sort of thing, yes.

...the Northern Hemisphere, seventy. And when you came to write this up, you wrote that the, you thought that the CFCs represented no conceivable hazard, and we now know you meant no conceivable toxic hazard...

Yup.

...which is what you felt. And you said that you, you sort of consciously wrote that because you felt that if you didn't write that, political Greens would have seized on it in, in the, the sort of way that you've spoken of. And I was wondering where your consciousness that the, the Greens might do that came from. In other words, when you were writing the paper and thinking, unless I say that, then this is going to be exaggerated into a sort of toxic hazard, where did your sense that the Greens might well do that come from at that time?

Well, the Green movement was always looking for chemicals of industrial origin that were a threat to mankind, do you know what I mean? It was part of their political scene. And, there was one particular American Green called Barry Commoner, who was not only very hyped up on this kind of attack, but he disliked me personally, so much so that when we were both at a Nobel Symposium in Stockholm, they've got nothing to do with Nobel prizes, it's something... prizes; it's something run by the Nobel Foundation, they have air, air... well this one was on nitrogen I think, the nitrogen cycle in nature. And I gave a paper there, and Barry Commoner gave a paper there. And we all had to appear in Parliament, each in turn, and say a five-minute piece before the King of Sweden. It was one of the rituals that they have, all rather fun and rather nice. And I did my bit, and the others did their bit, we were perfectly all right. And, Barry Commoner, curse him, made a diatribe against me in the course of his thing. God knows why. But he was like that, he was slightly mad. He had camped outside the Vatican for two days and got all the media interested, because the Pope wouldn't see him. This sort. He was that kind of a person with, [laughs] ego problems is the only thing I can think of.

What were, what were the grounds of his dislike for you then?

I have no idea. It could have been quite... May have been something I had inadvertently said in my lecture at the, either at the, in the Parliament or beforehand. There was no telling really.

And when did you first become aware of this dislike for you? You said, I mean the paper that you're, you're writing after the Shackleton is, sort of, 1972, and you're aware then that if you, unless you say this represents no toxic hazard then...

Well I, I had a strong sort of feeling that Barry or somebody like him would immediately say, 'Look! this chlorine compound's in the atmosphere, we're all breathing, we're all under threat of cancer. Dreadful.' This kind of nonsense. And the Greens were too good at that. And they would take the numbers I had produced as evidence that everybody was under threat. And people are innumerate, I'm afraid this is the awful trouble, and they cannot see the difference between, if you can detect something, then it's there, and it's a danger. They don't take into account the fact that

a part per trillion may be an utterly insignificant toxic hazard, even of a toxic compound, and the CFCs weren't even toxic. And, it's that innumeracy that bothers me with the Greens. They're unscientific, and they jump to anecdotal conclusions that have no real value or significance at all.

[31:16]
Was there, was there particular reactions from the Greens to another chemical that was in your mind when writing this paper about CFCs that you thought, they'll behave with CFCs like they did with this other thing.

Yes.

Was there something else?

Oh there was very much. You see, one of the things I had found on my voyage in the ship was a natural compound, that was very interesting to me, because it was connected with Gaia, and that was methyl iodide. And in places in the sea lots of it come out. Now that is a known carcinogen. [laughs] And, it, it tickled me to think that in theory some of the more crazy agencies like one of them in America would have forbidden sea bathing if it had been an industrial compound. Because of the, it would be dangerous, according to their sort of daft ideas, to bathe in the sea merely because it had a carcinogen in it.

Mm.

But because it was natural, of course, [laughs] that didn't occur.

Yes.

There's a lot of utter stupidity. And it's very similar to the anti-radiation stupidity.

Mm.

People are frightened of levels of radiation that are utterly harmless, merely because the instruments are sensitive enough to measure them and you can put a number to it.

[32:30]
Thank you. In your autobiography you say that when you, immediately you come back from your voyage on the Shackleton, you're, you're drawn into a world of industry scientists. Could you explain in practice how that happened, how those relationships were formed?

Sure. I was invited that summer, after the thing, to what's called a Gordon Conference, they have them repeatedly. They're scientific conferences, not only industrial, but a lot of industry scientists go along to them. It's a general thing, they're very nice conferences, in New England in the summertime, and they're held in schools up there mainly that are empty because the, the youngsters have all gone for their, away for the summer holiday. And we occupy their sort of dormitories and meeting rooms. And it's in gorgeous countryside, and you can go and spend, the afternoons are spent on hikes up in the mountains or swimming in the lakes.

Mm.

And, you work in the mornings and you have papers and things in the evening. It's a very very pleasant sort of conference. And I courted them, [laughs] I was only too glad to be invited along. So I told them all about my Shackleton measurements and stuff. And amongst the people present were two important scientists, one was Ray McCarthy, who was head of the fluorocarbon science industry at DuPont. Another was Lester Machta, who was a very senior figure in NOAA, the National Oceanic and Atmospheric Administration, who was, I knew as a friend, and he was fascinated with this thing, and also the decline from north to south, and I'd used some of his maps in devising that. And he was the one that told Sherry Rowland and Mario Molina about the CFCs in the atmosphere, and, which led to the whole ozone story.

Mm.

Because up to that time, I had no idea at all about that. I mean that was, completely came out of the blue.

Yes, the, the story that, from 'The Ozone Crisis', a book that I can see on your shelf there, is that, yes it was your measurements that, that sparked the interest from Molina and Rowland...

That's right.

...that ended up being in their paper.

That's right.

1974 paper.

Yes that's right. And, yes. And it was Lester Machta that was the bridge.

I see, thank you.

But, the sad thing was, that I had no personal contact with Mario Molina or Sherry Rowland until, we'd both been locked in battle more or less, because the whole affair polarised just as the climategate has polarised the, the climate affair.

[35:24]
Mm. So, the conference, what is the link between the conference and feeling yourself drawn onto the, the side of industry scientists?

Oh I wasn't drawn onto it. I mixed with them.

Yup.

That's all I said.

Right.

It was, Ray McCarthy was a very important one. There were other industry scientists there, who were interested in my results on the *Shackleton*.

I understand, yes.

And I'm sure some of them thought of the political consequences it might have.

[35:51]
Mm. Yes. And, you read the, the Molina, Rowland-Molina paper...

Of course.

...and then decided to measure levels of CFC at...

Well I...

...levels in the atmosphere above.

That's right. I'm an experimental scientist. My first thought on reading it, this seems a good, plausible scientific hypothesis; let's test it.

Mm.

And their whole theory depended on the fact that the sink for the CFCs was in the stratosphere, where also ultraviolet broke them down. So if you went into the stratosphere, you ought to be able to measure a lower concentration of CFC. Now, I immediately went to the Met Office where I had a lot of friends, one of them was Adrian Tuck, a famous atmospheric scientist, now at, actually at Colorado, but then at the Met Office, and asked him what chance there would be of getting, putting my gear on the RAF... not the RAF, the Met Office Hercules that did that sort of measurement. And he said, 'Well yes, we'd love to do it. In fact we **will** do it, we'll set in mo...' He said, 'The only trouble is, it'll take two years before we get it through health and safety and all the, all the other kind of bureaucratic...' I said, 'Oh that's no good, I

want the answer next week, preferably.' And so I was grumbling about this at the next MI5 meeting I went to, and one of the SAS people, who happened to be along at the meeting, because we, this was, we were dealing with Northern Ireland problems, said, 'Oh,' he said, 'I think we could fix it for you.' And I said, 'How?' And he said, 'Well we've got a Hercules at Lyneham that's going up on a test flight. I think it's next week.' And, he said, 'I know the pilot quite well. He'd be only too glad to take you along with him.' And, I think at some point I said, 'Well how much is this going to cost?' He said, 'Oh just a boxful of whisky for the crew. That'll be more than enough payment. It's fun for them anyway to have a boffin along doing something.' [37:55]
And I went up to Lyneham, a preliminary thing, and, told them what I needed, and the chap said, 'We've got an old disused pitot-static tube up in the front of the plane.' That's, that's the flight engineer. That's the tube that's used for measuring the forward velocity of a plane, measure the pressure of the air going... 'This would be ideal for you to sample from.' And, whereas, the RAF... sorry, the Met Office plane, it would have all been having to make a hole in the side to put the tube through, and that, that's where the health and safety and everything else held things up.

Ah.

[38:35]
So, anyway, they took me up in their plane, and they did all sorts of funny manoeuvres, because it was a test flight. We wanted to see what, if it could reach its ceiling, which was 45,000 feet, which it did. And that was ideal for me, because the stratosphere started at about 28,000 then. So I was several miles into stratosphere. And it was published in a *Nature* paper. And it shows, the moment you go over the stratosphere, the CFCs start falling off, falling off, and they get quite low by the time you got up there. So Molina and Rowland's theory was absolutely right. But the extraordinary thing, it was never quoted by them.

Mm.

There was no contact at all between me and the American scientists. They would not recognise that I existed. It was, the polarisation was so great already. I was classed as

somebody who knew industry or had something... and therefore, anything I said was useless.

[39:30]
Why do you think it wasn't quoted, even though it supported their theory, even those measurements supported their theory?

Because it... God knows, but if you were not one of the gang so to speak. We're very tribal animals, and you're seeing the same thing happening over the climate affair, and there's the sceptics who are on one side and the... Science isn't like that. The truth can come from anywhere.

Who else was in Molina and Rowland's gang at that time?

It... well they weren't a gang. It was just, the whole bunch of academics in America tend to form a group of cronies. They do the same here. And if you belong to that group, then that, you will be in, you're part of the in team. They don't go outside and ask non-team members for views on anything.

Mm.

It's... Rowland admitted many years later that he was, he would have loved to have seen the paper, but nobody showed it to him. I had no contact with him. I suppose I should have sent him a copy, but, I, I thought, well, it's *Nature*, he can read it.

Yeah well... I can't, I can't see why he wouldn't have had access to it, or why anyone would have needed to have shown it to him.

Well somebody might have shown it to him, but added, 'Oh but it comes from Lovelock, and he works with DuPont.' And that would have been enough. 'Oh no, we don't have anything to do with them.'

Mm.

It's like that, it's that kind of, absurdity really.

Mm.

And you get this all the time. It's, it's tribal behaviour really. And scientists are as prone to it as any other group.

Mm.

You get it in religions, that's why they've split into so many sects.

Yes.

And, that, that was it. But it was a wonderful flight in the Hercules, I really enjoyed it.

[41:17]
Can you explain exactly, in the way that you've gone into detail in explaining how you collected measurements in other ways, how... I know that there's this tube in the front of the aeroplane; I know you've got your, your equipment that you're now used to using to measure impurities. Could you join those things up and tell me how you took air samples and measured them on the plane?

Oh it's hard work. I had stainless steel cylinders, into which I could put the... I collected the air into great big fifty-millilitre, or may have been 100-millilitre, glass syringes. And of course, at that height, the air, the air in the, coming in was quite low pressure, so, you, you had to suck the air sample in, and then compress it by squeezing the syringe so that, to get it into the cylinder so that it was above atmospheric pressure. But this was possible, it was just, needed a lot of fiddling around in some rather crafty valves that stop things leaking or getting in the wrong place at the wrong time. And it wasn't too hard, I collected a whole set of these cylinders on the way up, and down. And, that, when I took these cylinders home, it was very easy to get the sample out of them, because they were slightly above

atmospheric pressure, and I could just run it into the gas chromatograph and that was it. It, it wasn't an onerous thing, just needed a bit of thought.

[End of Track 10]

[Track 11]

Could you explain how you came to be measuring natural sources of chlorofluorocarbons rather than merely industrially-produced or human-produced chemicals?

I'm wholly unaware that there are any naturally... [laughs] You've got a paper for, in *Nature* for yourself if you know of one somewhere.

Ah. I... Where am I getting this from then? I've... In the autobiography, it says, in September '76 you prepared a gas chromatograph... oh, specially for methyl chloride analysis. Oh perhaps this is what made me...

No, you see that's a natural, naturally-occurring hydrocarbon. Oh, a halocarbon.

Right. OK. So could you just, discuss your decision to measure those?

Ah. Well this all goes back to Gaia work. In the early days of the Gaia hypothesis, when, just, let's suppose that the system runs itself, one of the few things you could get an angle on, I mean it's difficult to measure what's happening to the climate, it takes long-term observations and those are a bit dodgy anyway, as we've been discovering. And, the one thing you might be able to get at, are chemical cycles. That's to say, it would be, according to the hypothesis, it will be necessary for life in the ocean to return to the land, those elements that were washed off from the soil, soluble, that have soluble anions, that are washed off by the rain that's always falling on the continent. And two elements immediately come into mind in this category, they are the sulphur and the halogen elements, chlorine, bromine and iodine. And, you see, they form soluble salts in water, the sodium sulphate, or even calcium sulphate come to that, and they get washed down the rivers into the sea. And on the whole life on the land is deficient in those things. It's particularly deficient in iodine, and, the disease goitre, very enlarged thyroid glands, is quite common in the middle of continents, a long way from the sea, where iodine is in very short supply.
[02:40]

So, it occurred to me, well let's have a look, first of all around the shores, to see if there are things emitting these volatile compounds of these elements that would go in with the wind onto the land and then oxidise in the atmosphere or something and deposit their burden of whatever element it is, and this will redress the, the lack of them on the land. And, I soon found just even in the literature that a chemist at, in Leeds I think it was, Challenger, had already demonstrated that quite a lot of marine algae, especially the big seaweeds, produce hefty quantities of dimethyl sulphide. And, one of these algae, Polysiphonia fastigiata, which is a kind of fuzzy epiphyte on the big bracts of bladderwrack and things, was a particularly potent producer of dimethyl sulphide. And so I went along the seashore at Adrigole collecting various seaweeds and put them in jam jars and sampled the, [laughs] the air above them to see what gas it... Soon confirmed Challenger's stuff, that dimethyl sulphide was pouring out. But then, I found with Laminaria, the great long strops, like an old-fashioned razor strop, leather strop, the stuff called, that you get there, poured forth methyl iodide, which was very interesting, because it's the kind of chemical you would only expect in a, in an industrial plant or an organic chemical lab; it's not the kind of thing you expect nature to be handling. Even more remarkable, in some of the areas around the coast, carbon disulphide was being emitted. Now that's a horrible smelly compound, I don't know whether you know it.

No.

Vile smelling stuff, and very industrial. Well apparently it's coming up in the sea. And years later, a young woman in Sweden, who I, who got a PhD, I was her external examiner, so I know what she was up to, she went out and found bromoform was being made by marine organisms, and, that's CHBr3. And, so, I was already interested in that. And so when I went on the *Shackleton* voyage, I arranged that in addition to looking for CFCs, I also looked for the emissions of methyl iodide, dimethyl sulphide, and anything else that I could find on the voyage.

[05:31]
Using the same equipment?

The same equipment. You can't measure the sulphur compound with an ECD; I had to use some, a different technique altogether for that.

Was that related to you dropping a teapot on a piece of string into the water?

Sure. Yeah, getting water samples.

And then what did you do with the water sample once you'd pulled it up?

Ah. Well, it's an interesting question that. For things like methyl iodide and the fluorocarbons, because both of those are interesting in the water, you've first of all got to, you can, for example just shake it up, and then... fairly vigorously, and then in the air space above the sea water you can take a sample with a syringe from it, as before, and analyse it. But what you have to know is what's called the Henry's law coefficient, that's the ratio of the amount of substance that's in the air, in equilibrium with whatever is in the sea. And it's very easy to find that experimentally and I did it on the ship. All you have to do is have a big fifty microlitre syringe and carefully half fill it with sea water, shake it up, take a sample of the gas above the space, then... [pause] Now, do you know, I've forgotten how I did it. [laughs] It's a long time ago. It's written in the papers. How, how do I...? You, you repeat this measurement a number of... Oh yes, you put nitrogen in on the top, that's right, instead of air, and, you shake it, you fill it up with sea water first and then put in fifty millilitres of nitrogen, shake it up, and sample it. Then you, you sort of squeeze out all, push out all of the gas above it, and re-fill it with another lot of nitrogen and shake it up. And do that repeatedly. And if you plot that, the amount on a graph, you, the slope of the curve gives you the Henry's law coefficient, and from that you can work out the exact amount that was in the sea.

I see.

That was in equilibrium with what was in the air. And this I did on the *Shackleton*, and it's reported.

Mm.

[07:52]
Now for the dimethyl sulphide, it was a lot more difficult. What I had to do with that was to extract all of the dimethyl sulphide from the sea water, and then store it in sealed vessels that, that were put in the ship's refrigerator, and they were kept and collected, and we analysed them separately after the ship had returned. Because there wasn't any instrument I could have taken on the voyage with me that would have been sensitive enough to detect the dimethyl sulphide.

[08:22]
And what equipment did you have to use when you had come back in order... that was more sensitive?

Well, a classic bit of, how can I put it, independent scientist's way of looking at things. I could have bought an exceedingly expensive special set-up for doing sulphur analyses with a gas chromatograph. Instead of which, the Gas Board sold a simple, incredibly cheap, I think it only cost about £10 or something, gas chromatograph, that was specifically designed to check the amount of odorant, you know, the smelly sulphur compound that makes a gas leak smell, that was in the gas. And, this was a sulphur detector. It was a flame photometric detector. And believe it or not, for a mere £10 or so you could buy this instrument, and it had a, a beautiful photomultiplier cell in it, and a hydrogen flame that burnt the gas coming off the column, and then looked for the emission of the sulphur lines in the flame above it. And this gave you a measure of the thing. So that's what I used.

[09:39]
Sorry if this seems a very very sort of technical point, but I'd be interested if you could tell me how you, how you labelled the samples on the ship that were put in the refrigerator in such a way that you were able to interpret and understand what was taken when, when you got back to the lab and you were faced just with the containers. So the process of notation or labelling involved in making sure that what you did on the ship was understandable when you got back into the laboratory with the samples.

Why should it be so difficult? All you had to do was put the time and date.

On...

The label.

On sticky labels on the...?

Mm.

Mm.

That's all.

Mm. Thank you.

That's enough.

OK.

I mean you could add a note which would refer to some remark in your lab notebook that you, you kept during the, the voyage, that, that, when you took this sample there was bladderwrack floating in the water, or some... you know, something that would relate back to specific... But if it was just plain old seawater and the rest of it, you only needed the date because the ship's course was logged and you had a complete record of where you were at at any given time.

[10:57]
Thank you. Now, hopping now back on to the, onto the ozone war, if, if we accept that description of it. Could you describe the meeting at Logan, Utah, in 1976, which, according to your book...

Oh a horrible meeting, yes.

...had at it stratospheric scientists, environmental lawyers, politicians, and a small group from industry.

That's right.

Could you, could you describe the arguments, and when I say arguments I don't mean necessarily, you know, violent disagreements, but I mean the scientific arguments that took place, and how they were made? In other words, what, what was shown as evidence in order to make particular points and, what particular images or sets of data or, graphs or lines or inscriptions were shown by each of them to make a particular point about this?

Oh, right. Now this was a, what I would say, was a grand meeting of the modellers and theorists on the CFC affair. There were some industry people like Ray McCarthy was along, as one, to just, at least know what they were all up to, [laughs] so industry was warned beforehand of any further mad shenanigans. And, there might have been one or two people who were actually doing measurements. I don't know whether there were. I was certainly doing measurements, probably at Adrigole and other places, so I was there to say, talk about that if necessary, but I wasn't asked to talk about that. I talked, I forget what I did talk about. Except that, in my talk, there was a lot of discussion about, oh yes, about the dangers of ultraviolet light, if, if the radiation from the destroyed ozone layer came through to the Earth. I was very dubious about this, and also about the evidence that the Greens and others were presenting. Much of the evidence they were presenting was to show that, as you approached the southern latitudes, so the incidence of skin cancer rose and rose and rose, and, you didn't get it so much in the north and so on. And, I, I produced a graph, I've probably got it around somewhere, where I plotted against latitude on one side, the incidence of a whole range of diseases. And, and also, a range of conditions, not only ultraviolet light but also amount of radicals in the atmosphere, free radicals and things of that sort. And the upshot was, it showed that the, for quite a few diseases, they increased in severity as you approached the Equator, the skin cancer. However, others, like multiple sclerosis, showed the opposite effect, [laughs] they got less as you went towards the Equator and worst in the north where there wasn't much ultraviolet. And, anyway, I thought this was, you know, to try and give some balance

to the picture. It wasn't as simple as the Greens were saying. Because they always think in simplistic, one, one single variable terms. I don't know whether they've got feeble minds or what it is, but they don't seem to want to, or, or are able to see it as a big picture. Anyway, I put that up.

[14:31]

I was soundly trounced by the chairman of the meeting. He said, 'You can't present that data here, you're not medically qualified. And, I mean, it was typical tribal stuff. The group of modellers, it was just like now with climategate, if you weren't for them, you were against them. And, it was quite bad for science, very bad indeed. It so happens of course I was medically qualified, I have a PhD in medicine, but he had not bothered to find that out. He had just assumed I wasn't.

Who were the modellers?

Oh, all of them that... They're all in that ozone book, you can borrow it if you like to look at it. Because... And you can sort of get their characters from the descriptions of the people. But they all were getting support grant funds, some of the money came from industry incidentally, to build models of what was happening in the stratosphere.

[15:32]

How would you... I can look in the book and look at their descriptions of these people, but what was your impression of them, these model... these scientists?

They varied. I mean some of them were good, straight scientists and doing their best; others were, [laughs] just in it for the money, because it was, it was, if you were a hungry scientist, it was a way of getting grant funds, this was a big issue. And it plays a very big part with scientists, you've got to find a source of funding.

Mm.

And, it pays to work on a fashionable subject, you get grant funds for it. There were others who were sort of committed Green people, even though scientists, who just wanted to prove how dangerous the destruction of the ozone layer was and how it

would lead to the destruction of all life on Earth, this kind of thing. It was a wide range.

Mm.

Typical. But there was nobody giving the other side, apart from me.

[16:33]
And was there something specifically American about these modellers as scientists, in other words, about the way in which they presented scientific knowledge, the way in which they conducted themselves at this meeting or conference? Is there, was there something specifically American about that science?

Only in time. I think that we were much calmer scientifically in those days. You went to an equivalent British meeting, people would not be so forthright or, or emotional about, about these issues. But that's changed. There's no so much to distinguish one of our meetings of that type from the American one now; a matter of timing more than anything. I think we, in the older days, perhaps I'm prejudiced, but we seem to present a more objective scientific view of things that, there was a kind of view I was brought up with, you shouldn't let emotions or feelings about, would a thing interfere with your science. You should always check every possible angle and if there's anything contrary to it, you should look at it as closely as you could. But there was a kind of, tribal, more like a, if... You know, as I said, if you're not for us, you're against us.

Mm.

Any evidence that was contrary to the great big happy idea that we're endlessly destroying the ozone layer, was, again it all goes back to a kind of simplistic, left-wing ideology, that industry was bad and out to screw us all, and, we, we were the white knights trying to prove there how wicked they were and stop them.

Mm.

And any, any story to the contrary was, was bad news, and you didn't have it, you wouldn't listen to it.

[18:20]
And, what was emotional about the way in which the modellers were presenting the results of their models, or the predictions of their models?

Only, they got emotional about the stuff for example that I had produced on the *Shackleton*. It can't possibly be right, because it shows there's a sink in the Southern Hemisphere. It doesn't show anything... Sorry. It shows there's a sink somewhere that's causing the fluorocarbons to go away. Why else would there be more in the Northern Hemisphere than the Southern Hemisphere? And they argue strongly on this point and then produce their own graph showing a totally different distribution where there's hardly any change between north and south.

What was that based on, that distribution?

What...

Yours was based on measurements taken on a ship...

Well theirs was based on measurements too. But they, they... I mean they did crafty things like, [laughs] one group took, started their measurements in San Diego. Now Americans are very ignorant. I'm sorry, I shouldn't say this because there'll be some listening, but they're totally unaware they're far south of Europe. Most, most Americans are. They, they cannot understand that San Diego is as far south as somewhere in Africa. [laughs] They're quite... You cannot get them to believe that Ottawa for example in Canada, which they think of as far north, is, is at the same latitude as Milan.

Mm.

It's a kind of ignorance, a geographical ignorance. I think geography wasn't taught much in schools in America or something like that. Or they weren't interested. But

anyway, of course, there's a hell of a difference between starting your voyage from Barry in South Wales and starting it from San Diego.

Mm.

You're so much nearer the... And had they taken the trouble to look at latitudes of my *Nature* result, they'd have seen that by the time I was at the same latitude as San Diego, they were getting, I was getting much the same result as these were. So, it wasn't an argument at all. But they turned it into an argument, to show that my results were wrong.

And were they using the same equipment as, as you were? Were they using your equipment?

In, in this case, the one that was presented, was done by the Navy, US Navy laboratory. And, they, they were using an equipment made on, on, with advice from me.

[20:45]
Thank you. Could you, as you've, you've mentioned this as part of your argument at this meeting, could you comment on the extent to which concern for ozone depletion could be argued was a, a particularly self-interested concern of light-skinned humans concerned about cancer? In other words, was there almost a kind of environmental imperialism going on in that ozone was being interpreted as a threat by people who were peculiarly vulnerable, that this was a, this was white humans concerned about ozone? Is there anything in that? I just sensed, I got an impression that you might regard the concern with ozone as a, almost a, a white, a selfishly white human way of understanding the problem.

Well it would have made sense, because it's only white humans who are enormously affected. The ratio is, is incredible, the difference in sensitivity to ultraviolet between, shall we say, a typical slightly freckled Irishman and an average Japanese is over a million to one.

Mm.

[laughs] Gives you an idea of it. Even... Because you wouldn't call Japanese black.

No.

They're darker skinned, but it's enough to give that a million-fold increase in protection.

So... And, if we're thinking about the American scientists who are arguing for the ban, we're talking about light-skinned human beings, we're talking about white Americans?

There is an apocryphal tale as the reverse of that story. Because, in those days I used to go to South Africa a lot, mainly because it was the nearest place to Britain in the Southern Hemisphere, and you could travel directly by air to Cape Town, without any time change, so it wasn't such a, an onerous journey as some of them, and Cape Town University and the government labs around there, South African Government, who were very helpful I might add at that time, had liquid nitrogen and all kinds of things for taking air samples that I needed. And also provided transport to take me out to Cape Point and isolated parts for air sampling. So I was going there not... And it was during one of those visits I heard a tale which I found very funny there, [laughs] that somewhere in Soweto there was a big poster up saying, 'Buy a spray can and knock off Whitey.' [laughs]

Really? Mm. Mm.

Which I thought was... Because that's the reverse side of the coin.

Yes.

I don't know whether that was true, but it would have been a lovely bit of propaganda, that was fairly harmless, and...

Mm. Mm. Thank you. OK.

And I would like to think the people in Soweto had the wit to do that. [laughs]

[23:50]
Lovely. Now, could we now hop to another key event I think, and that's the Congressional hearing at which you first met Sherry Rowland. And, I know this is going to be another...

I hardly met him.

Oh.

He was sort of the other side of the...

Or, or observed, saw him. Yes.

Yes, caught.

Now, I realise that this is another, this isn't another pleasant memory for you, but could you describe that moment?

Yes. I was called, I think, by DuPont as a witness for the defence. Because there was a hearing to, to discuss the US Government's banning of the emission of CFCs. DuPont told me right at the beginning, there was no way they could pay me for this, because it would be considered, you know, corrupting a witness. And I fully understood that and accepted it, and always have done in all of these things. I might add here for example, I strongly supported nuclear energy in this country, but was quite often offered money by the industry but would never accept it, nor ever would, would think of doing so, because it would destroy my independence. And, so, that, that, having said that, I appeared as a witness. My expenses were paid, and I don't know whether it was the US Government that paid them or, or DuPont, although, it's neither here nor there.

Mm.

My expenses were paid, and hotel bills, as far as the meeting was concerned. And, I appeared before Congress, and that was it. Naturally I appeared with the lawyers for, for DuPont, I mean they kind of introduced me to the, to the meeting, because I was the defence witness. And, it was a Congressional hearing held by, or the lead figure, the chairman, was Senator Rogers, I remember him well. And, Sherry Rowland presented the case for the damage caused by the CFCs and why they should be banned as soon as possible first, and made a strong case. But it was heavily scientific, there were lots of equations and things, and, mentions of things which I find all slightly irritating, like C-sub-Z being one of the factors in the eddy diffusion equation for, relating to the rate of transfer of CFCs from the troposphere to the stratosphere, that kind of stuff. And it clearly irritated the senators, there was no question about it. They didn't want to be, have a scientist preaching to them in, in arcane language. So, he really didn't do his cause any service by that kind of presentation.
[26:40]
And, I realised what was going on, [laughs] and I could see their faces, and when I got up I thought, oh Jim, you've got to make this simple. And so I came up immediately when Senator Rogers asked me, 'Well Professor Lovelock, what do you think of Professor Rowland's model?' and I said, 'Well Sir, to me a model is very much like a recipe for baking a cake: everything depends on the ingredients that you put into it.' The chairman then said, 'Well, well, what ingredient is Professor Rowland put in that he shouldn't have done?' And I said, 'No, it's the opposite way round Sir,' I said, 'he's left out an important component of the mixture,' and, that is the gas methyl chloride. I just measured its abundance in the atmosphere, and it's over 500 parts per million, which is nearly ten times more than the CFCs in the atmosphere. Admittedly it contains less chlorine than the CFCs but it's still the major source of chlorine to the stratosphere. And this is a natural compound, and probably has always been there, and we're not suffering any ozone depletion now. What are we worrying about? Clearly, I think that although the CFCs may represent a threat, we have quite a bit of time in order to decide when, when to remove them from the air or not. And, moreover, it will be very dangerous to ban them suddenly, because it would mean there would be no supply of essential refrigerant, and it would mean that refrigerators and air-conditioning all over the world would begin breaking down if there was a ban

on CFCs. And this would cause far more deaths I think than lack of, of ozone. And so naturally they gave them a two- or three-year stay of execution. I've forgotten the exact detail.

[28:33]
What was the, the response from, well perhaps Rowland and, and the American modellers?

I don't know, they must have been absolutely hopping mad with me. And it wasn't long afterwards before newspapers, even British ones, were referring to me as a 'bought man of industry'.

Mm.

Which was a gross libel. I mean no way was I bought then. But I just wasn't on the right side.

Mm.

You see, the issue had become polarised, as it always does when Green affairs come into things.

Mm.

They become politically polarised.

[29:04]
And, is it correct to say that the, the Chemical Manufacturers Association who provided grants were providing grants for all sorts of research, so...

Sure. They, they supplied a grant to me for the Adrigole station.

Mm.

But this was a recognised grant-funding agency that, that provided money to everybody on both sides. They had to. And, the judges of the committee were independent academics.

[29:36]
Were you aware at this time I wonder of the, being someone who was interested in making long-term measurements and interested in making measurements, however small a scale the operation was, or however home-made it was, were you aware of equally sort of, relatively small science observations being made by BAS at this time?

By whom?

By British Antarctic Survey, with the spectrometers. In other words, the, Farman's group of people. Were you were then of their measurements taking place?

Oh yes. I mean, one, one of the things... I was measuring the abundance of halogen containing compounds in the atmosphere. Not only CFCs but other quite important compounds like methyl chloroform, which was an industrial product, solely, it had no natural source, and was just as much a threat to the ozone layer as some of the other things. And that was building up steadily in the atmosphere. I was also aware that others were looking at the ultraviolet intensity coming through in North America. My friend Lester Machta of NOAA was heading a, a big study of that. And, others were, like the British Antarctic Survey, were keeping a watch on the ozone level above Antarctica. I'm not quite sure what was the prime scientific motivation of that. But they used what was called a Dobson spectrometer, and, it was a, a device which looked up and observed the solar, the sunlight filtering effect of the ozone up above the sky, and therefore, thereby gave them, gave one a measure, a direct measure of the thickness of the ozone layer.

[31:30]
Mm. Thank you. Would you be able to describe one of the last things that you did in terms of the ozone work, which was the, the building at Coombe Mill of the chamber in the barn to calibrate the instruments? But perhaps first you could mention the role of Coombe Mill more generally in allowing you to continue ozone measurements, in

other words the reason for moving to Coombe Mill, or part of the reason for moving to Coome Mill, and then go on to discuss the, the actual practice of setting up the chamber and operating it and doing what you wanted to do with it.

That's right. The two measurement sites that I had charge of myself were the holiday cottage at Adrigole, on the shoulder of Hungry Hill in Western Ireland, which was a, in those days, an extremely isolated and remote place, and I thought probably had some of the cleanest air in Europe, and certainly when the wind was from the Atlantic you could reliably think that it was giving you a, a measurement of the tropospheric abundance of whatever gas you were looking at. The other one, which wasn't quite so good but was still good as far as England goes, was Coombe Mill which was in far west Devon on the border of Cornwall, and not far from the sea on both north and south sides of the Cornish peninsular. And, when I moved here I deliberately bought an old disused mill that had a fair bit of land going with it. There was about fourteen acres when I bought it, and twenty acres became available very soon afterwards on the opposite side of the river, and these were added to it. And it's now about, just under forty acres of land. Now, this meant that I didn't have to worry in my laboratory at Coombe Mill about leaking refrigerators on nearby farms or, or houses. Indeed the nearest house to the Coombe Mill lab was a kilometre away. And, so, that was my prime motivation was to get as clean a site as I could for the measurements that I was going to make.

[34:00]
And these were measurements that were continuing, because you had begun to make these at, at Bowerchalke?

I had begun to make measurements at Bowerchalke, but one of the reasons for moving is, Bowerchalke a little bit near the big main urban centres, it's only twelve miles from the fairly big town, Salisbury. Whereas Coombe Mill was six miles from a tiny Cornish town of Launceston.

[34:22]
Thank you. And then, one of the, the buildings at Coombe Mill that was here I think when you moved in was a dilapidated barn. Could you explain the process of turning

that into something that would allow you to calibrate your instruments for measuring CFCs as a way of proving that it was an absolute measurement of CFC?

That's right. Perhaps I haven't fully explained. But the detector I used, the ECD, was an absolute device, and therefore required no calibration, if it was used in the way that I used it. But, I should add here, and this is very important, the commercial instruments that were sold, that according to my design had a software inclusion in them to make them easier to use, which meant that the instrument could be turned on and it zeroed itself automatically; the analyst didn't have to keep adjusting the thing and waiting until the baseline had settled down and that then they could get, see their peaks. Now, that invention that I had, of a different way of operating that made it easier to use, destroyed its ability to act coulombetrically and be absolute. So all the commercial instruments that were on the market required calibration.
[35:47]
Now, at the risk of offending homeopaths, it is not possible to make a dilution to a few parts per trillion manually, even of a highly unreactive compound like a chlorofluorocarbon. It would be utterly impossible to do it with more reactive compounds like a drug, that's parts per trillion. So, so, ultra, ultra-dilution is, it's really a mug's game, you can't do it. However, there was a way of meeting it halfway at that time, and that was a procedure called, what I, that I called exponential dilution. What I did was, in an old barn that was at Coombe Mill I restored the barn, got the builder to restore it, and in the upper storey of the barn built a chamber out of wood that was fifty cubic metres in volume, and the walls of the chamber were, were good, solid material, I'm not quite sure now what it was, but it was covered with several layers of an impervious paint that the paint industry had told me is unreactive to the sorts of compounds I was going to put in the air, and, it would seal the room completely. Now, into the air of this room was blown air from outside, clean air, and, I only did experiments when there was a westerly wind from the Atlantic, and I'd checked it anyway beforehand for what levels of CFCs it contained. Air was blown at fifty cubic feet a minute, so that the concentration of anything released in the barn would be steadily exponentially diluted at a very constant, known, rate. And I added as a trace gas a large amount of hydrogen, not enough to make it dangerous, but quite a lot, from a cylinder. Because you can measure hydrogen very accurately. So that measured the degree of, that backed up the degree of dilution, and, and so on. And

then, with a vacuum apparatus that I had in the lab in my house at Coombe Mill, I prepared a very small sample, I've forgotten the exact, but it would be a few micrograms, of CFC-11 or CFC-12 or any other one I wanted to release. And, this glass ampoule was broken electronically in front of, by an electrical banger, hammer, in front of a huge ventilation fan that stirred the air of the room and kept it moving so that the air cycled in about, a few seconds. And, to do an experiment I set the whole, the chromatograph that was sampling continuously the air of the room, taking batch samples admittedly, but, one after another automatically, set it running with the background, everything steady, then suddenly released the CFCs and watched how they, their concentration fell away. Well, by the time it had gone through two powers of ten shall we say, and it was backed up with the hydrogen falling through, you could take that sample and say, well this represents such-and-such a concentration. I could then compare it with my own standard detector and see if it gave the signal I wanted. And if it did, then, that sample would be put in stainless steel cylinders and sent off to other labs as a representative of a concentration of CFCs at such-and-such a concentration, that they could then use for calibrating their instruments. And this I did.

[39:33]
And those air samples then were sent to the other monitoring stations...

That's right. Yes.

...which were set up as the sort of, CFC network...

Yes.

...which entailed Coombe Mill and Adrigole...

Mhm.

...as the ones that you were closely involved in. But, there were other ones globally, or...?

Well, I was asked by the CMA if, was it possible to set up a global network of monitoring stations for the CFCs, that they could really settle this business of the north/south different by. And I said, 'I see no reason.' And I suggested what they did was, purchase for me a chromatograph to set up at Adrigole, a modern one, the very latest that Hewlett-Packard made at the time, new, that would automatically and reliably sample the air, and, without any, anybody there to bother with it. It would be an automatic monitoring station. And I said, 'What I need is one year to try this apparatus out, and see if it really works as, as we want it.' And that I did. I set it up and it worked like a dream. And then it was agreed to immediately set up similar stations in the following places: Barbados, there was a site that a colleague of mine, Peter Simmonds, went out and set up; there was another one at Tasmania, at Cape Grim in Tasmania, where there was a meteorological observatory anyway that was run by the Commonwealth Scientific and Industrial Research, CSIRO, in Melbourne, a very good lot of scientists; there was another one in Oregon on the west coast of America run by an American scientist called Rasmussen, who was very much involved in these calibrations and so on. And, let me see, was there an...? Well there was Adrigole of course. [pause] Oh yes, there was one other station, that was at Samoa, that was run by the NOAA, they had a meteorological station there, and there was one. So that was the, the... It was called the ALE, atmospheric long-range experiment network. But it was taken over in a few years and became part of a, a network of monitoring called GAGE, g-a-g-e, but I don't know quite what that acronym stands for, but you can find out.

[42:04]

So, my job was to set it up and get it running. Well by the time that was all completed, I was falling into ill-health, and my first wife was getting, was even more so, and we were finding journeys to Adrigole getting more than we could manage. So, I asked that the, the thing be transferred to Peter Simmonds, who, who was a colleague, and he ran it for about, two or three years, and then the GAGE was formed and they moved it from Adrigole to, a different place in Ireland, in Galway, what was the name of it now? Mace Head is the monitoring station there. That was, in some ways, a sensible thing to do, because at Mace Head they were monitoring all sorts of other gases, and it's always a good idea to have a lot of things done simultaneously, you can make correlations you couldn't otherwise do.

Mm.

And it still goes on as far as I know.

Can I ask two further questions about the, the monitoring stations and then we'll move on to talking about Gaia directly.

Mhm.

[43:12]
The first is, at the time before you were forced to give up the station through various sort of personal reasons, and you were sort of in control of, you were setting up these stations and then in control of making sure that the calibration was the same across them...

That's right.

What else was involved in making sure that everyone was measuring in the same way? In other words, what else was involved in controlling these sites at a distance?

Not... Well, it was right out of my hands entirely. The, the whole programme, once I had established it and set, shown that it could be done, was taken over then by an MIT scientist called Ronald Prinn.

What was involved in that case in setting it up so that each one started doing the same thing in the same way?

Well, I gave them the full description of what was being done at Adrigole, and they'd purchased the same instruments and the same, the whole, exact set-up, so that they were all doing the same thing.

Mm. And, the timing of it, how many... I know it was an automatic recorder wasn't it?

Yes.

How often would it take recordings?

I've forgotten now. Several times a day I would say.

[44:20]
The other question I'd like to ask is something that you've spoken to me about off the recording, and that is, the role of Adrigole, and in particular the role of the local community, and in particular the role of the particular farming family...

Michael O'Sullivan, yes. Yes.

Yes. I wonder whether you could expand on the relations between your work there and the involvement of him and his family and of the local community, if possible.

Sure. We, we... In 19... when would it be? '65 or '66, we bought a holiday cottage on the shores of Bantry Bay in Adrigole. It was, quite a modest, inexpensive purchase, and it was in one of the wildest parts of Ireland. The people were very poor in those days around there, the children of the family next door ran around barefoot even in the winter, and they seemed to live on a very thin diet indeed. It really, they were suffering a great deal of poverty in Western Ireland in those days. But we were accepted by the community, or, I would say even more than just accepted, welcomed, which was a big surprise, because, the English and Irish [laughs] are notoriously at war with each other. And more than that, we hadn't been there very long before the worst of the so-called Troubles, the Anglo-Irish war, began, with that frightful incident in Londonderry, the Bloody Sunday when troops fired on a crowd of demonstrators. At no time ever were we made unwelcome. Quite the opposite. I remember, just after the Bloody Sunday incident, I had to go over to Adrigole for some purpose. Because I was doing monitoring in a quiet way right from the very beginning. I could never go on holiday for any length of time without doing some, taking some science with me, probably looking at seaweeds and things like that.
[46:29]

Anyway, friends here said, 'For heaven's sake take the GB plates off your car if you're going to Ireland. You are just asking for trouble.' And I thought hard about it, and I thought, oh to hell with it, they're not like that. And, we left the GB plates on. And to my amazement, we had people come up to me, service station people when, when they filled up the car, and the villagers all around would say, 'Oh we're so glad you didn't take your GB plates off, we thought after all those troubles in the North you would be inclined to do it.' They said, 'What sort of people they thought we were if we'd kind of expected you to take your GB...' I mean, we...' [laughs] they said, 'We know who you are, you're British and we're Irish, and, so what?'

Mm.

It was a lovely time. It was a wonderful example of transcending tribalism if you like, and, it was nothing but good.
[47:25]
Now the family next door to us looked after our cottage when we were away. They were guardians. And, the wife of the family, Teresa O'Sullivan, became a really close friend, and, she was quite a, a prominent person along the peninsular, I don't know quite on what grounds, but she was sometimes referred to as the Queen of Beara, [laughs] and, Beara being the name they called the peninsular. And, they did odd jobs for us when we were away, odd building jobs, because the husband, Michael, was not only a subsistence farmer, he, he had built his own house and he had built the cottage we, we had bought.

Mm.

And we had an extension built on to house the laboratory equipment and stuff like that, and also another small one to give us a spare bedroom. And, we built up a working relationship. And I found him such a reliable chap that, I gave him the job of doing the, first of all recording the, some photometer readings, the haze density, right throughout the year. And he did it most diligently, I mean, better than any technician [laughs] would have expected. And, he was very proud of being asked to do this sort of thing. And he took charge of looking after the, the monitoring station when, the more complicated gas chromatograph equipment and all the rest of it, and he did the

job wonderfully well. And, he'd got his name in the local newspaper, the *Cork Examiner*, and whatnot, as doing this work. And he got the whole sort of operation integrated into that community and they felt a part of it.
[49:17]
It was very sad, because, after I had left and they moved the, the thing to Mace Head, there was no compensation, there was no appreciation, nothing. They just came in and took everything away and, that was it.

Mm.

It was the difference between personal and a bureaucratic way of handling things.

Mm.

And, I was... But we've retained a friendship with that family ever since. Michael O'Sullivan and his wife Teresa are both now dead. I, I live too long, [laughs] I mean, I might have more, too many of my friends have died.

Mm.

But, the daughters and sons of the family keep in touch, in fact I met one only a short while ago, who had come over to Britain and was, just wanted to keep, keep in touch.

[50:14]
Do you remember how his role was written up in the local paper, do you remember anything about the...?

I don't, not too, too much. I think, there's a picture you've probably got somewhere in the archives of me and Christine on the mountain, on the side of the mountain. Now that paper was taken, that was a picture taken by the photographer in the *Cork Examiner*, and was in... and it was in the article that accompanied it that Michael was, you know, his, his role was mentioned.

How were you referred to in that, the local paper, do you remember, as a, as a scientist, as a sort of...?

Probably, yes.

Right.

Yes.

And what did his work involve when he was running the more complicated equipment, what would his sort of... Obviously he was farming as well, but what would his daily work involve?

You could tell Michael anything that needed doing, give him a written list of the, the steps, and he would do it faithfully, and without any failure ever. And... but did much more than that. There was a hurricane came up, I forgot what year it was, but you can get some very rough weather right out there on the west Atlantic, and this was hurricane force winds. And there was a danger of the roof of the cottage blowing off. And this was at night. And he and the sons of the family went out to put ropes across the roof, to hold it down.

Mm.

And, it was so strong, the wind there, that on one occasion a stone wall, quite a sizeable stone wall, was blown over by the wind. No, it was... He did all sorts of things like that, to keep the station running.

Mm.

And it was a, a degree of dedication that, that deserved recognition anyway.

Mm.

[End of Track 11]

[Track 12]

OK, now, from at least the early 1960s with work at JPL on planetary life detection work until you published the first book on Gaia in 1979, I can imagine you involved in all sorts of things, and drawing together various ideas and images and thoughts and conversations and findings including those of the ozone work, and, bringing together all of these disparate sort of bits and bobs to start to produce a, a scientific theory, to bring together a scientific theory. And what I'd like you to do is to attempt to describe the effect of different things on the development of this theory, and I'll help you to do that by asking you about those different things in turn. If we get to the end of that and you think that I've missed some key aspects that were important in the development of the theory, then, I'll give you the opportunity to, to add them. But, could I start with this, and ask you to comment on the effect of seeing particular images or charts that you could only have seen at the Jet Propulsion Laboratories at NASA, the effect of seeing images generated through space expertise at NASA on the development of the theory.

Didn't I ought to start a bit earlier, how it all came about?

If you'd like to, yes.

Well, I was invited... What gave me my independence, if I haven't said this already, was the invitation from the director of space flight operations of NASA in 1961 to participate with them. I think I've mentioned that before, so I won't go into it deeply, and you can cut this anyway, it's... I went along to JPL regularly from then on from my base in Houston where I had moved to in order to... I didn't want to live in Los Angeles, it was such an unhealthy place to take a family to live, so, I just settled on Houston and commuted to LA.
[02:26]
Now, my first jobs were entirely instrumental, helping them with gadgetry to analyse the soil of the Moon and Mars, and make it space-worthy. Making it space-worthy is a terribly important thing, and I think one of the large contributions I made may seem terribly small but it made possible a lot of the Martian data-gathering. I, I was in a room... Often I was with the engineers on these things, not with the scientists. And I

was in a room with the communications engineers, and they had the problem, they said, 'Well, how the blazes are we going to send your chromatographs back to Earth?' They said, 'Look at those typical chromatographs, there's about sixteen peaks they reckon they need on this. This is going to take us,' oh, so many kilobits. And I said, 'What are you talking about, so many kilobits?' And they said, 'But that's a... to, to repeat that as a visual image is going to use up that many... You couldn't do it with less, we've tried hard.' And I said, 'No, hold it a minute. Do you realise that the band width of a chromatograph column starts off at the very beginning at about one hertz and drops to about a hundredth of a hertz by the time it's got... You're not going to need more than about, oh, fifty or sixty bits to describe that completely.' And they were really first-class communication engineers, and as soon as they cottoned on to that, the natural fact that a chromatograph column is an ultra low-pass filter, they got the point.

Mm.

And of course you can send a whole chromatogram back completely by taking just two samples, one anywhere on the peak.

Mm.

That describes it completely. It cannot move any other way if you've got the two samples. [laughs]

No. No.

So that's how they were able to send the data back from Mars. Now, had I not known that thing, they would have been flummoxed for years before they found out the...

Mm.

No. But that was the kind of, a background. I was there mainly as an instrument designer and engineer, more than as a scientist.
[04:41]

But one day, after, about two years into my stay with JPL, maybe even three, the chap who used to give me a ride from the hotel I stayed at to the labs, called George Hobby, he was incidentally an understudy for Tarzan, and looked like him, [laughs] and, he gave me the ride, and he said, 'Jim, do you have some spare time because I'd very much like to take you along to a meeting of the biologists here.' He said, 'I think they're talking the most arrant rubbish, because they want to send instruments to Mars to find life, and, what they're talking about sending, would find life in the Mojave Desert where they do their experiments, but I can't see that it's going to work on Mars.' So I went along with him and sure enough he was absolutely right. They were asinine experiments, and... Well I don't think biologists are very good at designing that sort of thing, it's not their scene. And, they were just run-of-the-mill biologists who might otherwise have become teachers of biology in schools, and perfectly good at that, who had been hired by NASA on the grounds... Government departments often make a huge mistake, they imagine that if they hire fifty scientists they will get fifty times as good a result as hiring one. It's absolute nonsense. One good one is worth an endless number of, of average ones.

Mm.

And these people were never ever going to find a sensible way of finding life on Mars. Now after listening to them for several hours I said, 'Why are you doing all this? How do you know the life on Mars is even vaguely like the Mojave Desert? It might be in quite a different form. After all, look, it's all that distance away, it's had different chances of evolution.' And they got pretty cross with that, so they said, 'Well what would you do instead?' And I said, without thinking, 'Well I'd look for an entropy reduction on the whole planet, because if there's life there, it's bound to reduce the entropy of itself and its environment, and this is a great way of looking for life.' And of course, being biologists, they hadn't a clue as to what I meant by entropy. And that didn't help one bit. And the lead biologist I think it must have been went to the director of the Institute later that same day and said, 'Look, this character has got no business coming in on our meetings, interfering and upsetting everybody. We want it stopped.' And I was called to see him. And, he said, 'Look, I hear you're [laughs] upsetting all our biologists.' And he said, 'Look, NASA's hired these people at great expense to solve this problem; what the hell are you doing going

in there and stirring them all up?' And I said, 'Well, I think their ideas are crazy.' And he said, 'Well what would you do?' And I told him about the entropy reduction. So he said, 'Right, well, relate it to me in hardware. What bits of hardware are we going to send to Mars that'll look for an entropy reduction?' And, of course I was flummoxed then. I said, 'Well, you can't expect me to give you the answer now.' He said, 'Well you've got until Friday.' That was Tuesday. And I thought, great, my contract is now very much on the line, if I don't come up with an answer by Friday I'm through. And, on Thursday night it suddenly dawned on me. Because I was beginning to get very worried by then. Oh what are making a fuss about? It's so simple. All you have to do is to analyse the chemical composition of the atmosphere. That will tell you if there's an entropy reduction on Mars straight away without any further ado. And, the reason being, that if there's life on the surface, there isn't an ocean on Mars, that would be obliged to use the atmosphere as the only mobile medium, as the source of raw materials, and somewhere to deposit its waste. And doing this, using solar energy, which the light would have to do, there's no other force, would be bound to change it away from an equilibrium state. It would go from chemical thermodynamic equilibrium to a new steady state of chemical equilibrium which would be different and easily analysable from the composition of the gases. [08:53]

And, so I told him. And he got very excited. He said, 'For heaven's sake, write a report on this, this is pure gold.' And, I did, I wrote a paper for *Nature* that was published in 1965, it was called 'A Physical Basis for Life Detection Experiments'. And I was called to NASA headquarters, and they, they got equally excited about it, and, almost before I knew where I was, I was given the de facto, although not official, position of lead experimenter for the new Mars life detection experiment, looking for atmospheric changes. And, I was getting really worried, because within a couple of months I was being deluged by contractors with million-dollar-plus experiments that they were going to build for this, this thing, and, I was going to have to choose somebody or other. So I could see myself finishing up in jail [laughs] as a result of this. It wasn't my world at all.

Mm.

And I wasn't paid anything for doing it, it was all unofficial.

Mm.

It was a real kind of administrative mess. And it was an enormous relief to me when the biological lobby succeeded in squashing it all, and, in the September following, this appearance at NASA headquarters in April, the Senate cancelled that particular experiment and mission.

[10:22]
Who was involved do you think in stopping that among the biologists?

Oh, I, I suspect that the lead figures in stopping it would have been the Nobel Prize winning scientist, Lederberg, who was a very good biologist incidentally, but had his own agenda as to what the thing was. Carl Sagan was a close associate of his and followed... I think they were influential in, in, in... I mean there was no ill-feeling involved, it was just that, [laughs] that was their bailiwick, they weren't having anybody coming in from outside taking away life detection from them.

Mm.

And, I, as I say, I was relieved because the last thing I wanted was to get involved with a managerial, major problem involving possible corruption and God knows what else.

Mm.

So... Anyway, that was it.
[11:17]
But, in that September, strangely enough, the same time, it was, it was a strange period, that, I was in the lab at... in, sorry, in an office that I shared with Carl Sagan at JPL one afternoon, discussing these matters and others, along with a young woman philosopher, Dian Hitchcock, who was one of the most intelligent people I've ever come across. She picked up atmospheric chemistry in a couple of months to a degree that would make a, you know, a, a writer of papers on the thing. In fact we did write a

paper together on this thing, which was eventually published in Carl Sagan's journal, because he was, you know, a sort of, he's a good fellow and, although he disagreed with me, he was well prepared to publish. And, interestingly, that paper we both took to Lord Rothschild, because he was a Fellow of the Royal Society at the time and said, 'Would you be interested in submitting this for publication in Proceedings of the Royal Society?' He read it, and said, 'Yes, I'd be delighted to.' But of course, we didn't allow for the peer reviewers, who threw it out instantly, very rudely too.

Who were the reviewers?

I don't know. Well they're always anonymous. That's what makes them, allows to be so rude. They're usually disgruntled academics who...

Did you have your suspicions at the time based on other...

No...

You don't know.

I hadn't the slightest idea. But Rothschild was, oh he was absolutely livid, incandescent. He said, 'I'll never submit another paper to the Royal Society. They're a bunch of idiots.' [laughs] Anyway, it did get published, not that that makes all that difference.
[12:57]
But, the point was, we were in this room together, Carl Sagan, Dian Hitchcock and I, discussing the, you know, the whole darn thing, and taking a long-term view, oh well, we'll do something about it next year or the year after, when in marches another astronomer, Lou Kaplan, with a great big sheet of, pile of sheets of paper. We said, 'What's that?' And he said, 'This is really hot news.' He said, 'These are the infrared spectrographic analyses of the Martian and Venus atmospheres, and they show the complete atmospheric composition.' And so, my eyes lit up, I said, 'What is it, what are they?' And he said, 'Very simple,' he said, 'both planets are almost nothing but carbon dioxide; there's just bare traces of other things present, just traces of oxygen, nitrogen and so on. It's nearly all carbon dioxide.' And I knew instantly that Mars

was lifeless. It was an equilibrium atmosphere. And then when you compared it with the Earth's atmosphere, where you've got reactive gases like oxygen and methane coexisting. I mean this is madness, it's like the gas that goes into the intake manifold of your car, hydrocarbons and oxygen. I mean you can get energy from it. Now that's an immediate sign of, of low entropy.

Mm.

And, and so on. And, all of the gases, when you start looking at them, you find not only are either direct products of living organisms, like oxygen and methane, or, or they're like, carbon dioxide, have been massively processed by life. And carbon dioxide on Earth is a trace gas. This is incredible, because it should be, like Mars and Venus, the bulk gas, the major gas. So, there's no question that the Earth's atmosphere was massively at disequilibrium.
[14:46]
Now, the next thought that came instantly came to my mind in this afternoon was, well if it's that unstable an atmosphere, how does it stay constant? Not just year by year, but for millions of years. And, then it dawned on me, well if all those gases are made by life, life must be regulating it, keeping it constant. And, I blurted this out, and Carl immediately jumped and said, 'Oh that's a nice idea, but I think it's absolute nonsense, life couldn't possibly regulate the atmosphere.' And, then he said, because Carl was like that, he sort of said, 'Yeah but hold it a minute.' He said, 'One of the things that's really puzzled astronomers is the cool Sun problem.' The Sun was only thirty per cent as hot at the start of life, as it is now. So why wasn't it frozen then? We know the Earth has been more or less constant. So maybe something is regulating the climate. And it immediately came to me, well, anything that can regulate the atmosphere can regulate the climate, the atmospheric... As we know, just changing $C0_2$ by six per cent can potentially do all sorts of nasty things. So, any... if life can regulate the atmospheric composition, then it can regulate the climate and therefore the whole environment. And that was the Gaia Hypothesis, as it was then.

Was that the first time that they atmosphere of these, of Mars and Venus, had been measured?

Yes.

So this was very, this was very new...

Hot off the, couldn't be hotter off the press.

[16:24]
How was it measured, was it with a telescope, a sort of infrared...?

It's very interesting. It so happened that I was only able to get published, that *Nature* paper I mentioned, for the, the time before, because, a friend of mine, Peter Fellgett, was Professor of Cybernetics at Reading University, and, he, when I told him about it, he said, 'Oh don't worry,' he said, 'come and be a visiting professor at our department, and, they'll publish it all right if it comes from there, any future papers.' Which of course is true, it's an academic affiliation. *Nature* had bounced my paper back the first time I submitted it, on the grounds they didn't publish papers from home addresses; they mainly came from cranks. And when I explained who I was and that I'd been at Mill Hill, then the editor said, 'Oh well of course, you are that Lovelock,' and then, it was published straight away.

Mm.

[17:25]
And... Anyway, Peter Fellgett was an inventor himself and he had invented a very famous instrument called the multiplex interferometer. It was a way of using infrared to analyse things that was far more resolving, far more powerful, than any other way of using infrared. And it would take the whole light coming down the telescope from Mars, and then separated into all of its spectral components exquisitely well, without losing anything. Whereas the ordinary spectrometer, you had to send the light through a slit into a prism and then it would be divided up. And by the time you'd got to the divided bits it was so weak that unless you'd got a super big telescope, you couldn't do it. But this was done, the multiplex interferometer that Fellgett invented, was coupled up to a telescope in France, at the Pic du Midi, that was run by a husband

and wife team. It's quite, a fairly small telescope. And it was adequate to analyse the atmospheres of Mars and Venus. So that's where it came from.

Who were the husband and wife team?

Pierre and Janine Connes, c-o-n-n-e-s.

[18:39]
Thank you. I wondered whether the, the images, the photographic images of the Earth from space, made any impression of you around this time. They're often...

The icons...

Yes.

...of the astronauts.

Mm.

Oh enor... They, they of course, almost had a spiritual effect. I can't think of a better word. I'm not being religious, but, there seemed such an exquisite beauty about the Earth, that the dull dumbness of the other planets just totally lacked. I mean, as Lewis Thomas put it, we're so obviously alive when you look at it compared with the other planets.

When did you first see those images taken?

I can't remember. They became very common.

Were you at an advantage having connections with NASA in seeing them before...?

Probably. Probably. Yes.

Thank you.

But I don't, I couldn't say that for certain.

[19:30]
Now, the Gaia theory is a, a theory at a global scale. But I know you as someone who enjoys walking, has an interest in landscape, has an interest in particular places. And so I wondered whether you could comment on the extent to which Gaia as a global theory has been informed by engagements with very particular places and sites. And I'm thinking of the sorts of places that you might, that might have informed the theory as being places near to where you have lived or have had research stations, places you visited in travel, places that you visit as someone who walks in the landscape and has always walked in the landscape. And I wondered therefore whether there is a, a, a very very local source of your thinking which builds into a, a global theory.

There probably is, but I'm sorry, I can't sort of pin it down at the moment. Once I had formulated the Gaia Hypothesis as it was, it was, a hypothesis is just a, let's suppose, it's a theory, requires a lot more back-up, and it needs to suggest experiments for its verification or falsification. And also preferably should have a mathematical basis if it can have one. That sort of thing. And it took quite a few years before it evolved from a, a hypothesis into a theory. But...
[21:17]
Now everywhere I went, I was thinking of ways of, how can we prove it? And, I mentioned earlier the business of the cycles of the elements, the sulphur and the iodine and so on, and that was one step. There were, gradually as time went by other steps came along, but that wasn't until the 1980s and later, and one of the most recent steps of proof of Gaia theory came from ice core analyses by, a paper by two Americans, one of whom's a friend of mine, Ken Caldeira, [laughs] who didn't understand what they'd done, because they didn't realise it was a proof.

Mm.

But there you are, that was, they demonstrated the fact that the carbon dioxide and temperature must be simultaneously regulated.

[22:08]

Mm. I wondered whether, when you... I know in your autobiography you say that when you are thinking about things, you go for walks. So I wondered whether you, you looked at them, having formulated the hypothesis that life alters its environment, alters the atmosphere around it, I wonder whether you looked for examples of that in, natural habitats wherever you were going, and, one that I was thinking of as being important possibly was the, the beach at Adrigole, or at least the, the coastal area at Adrigole, and the, the seaweed there that you've mentioned, I wonder whether you saw very local habitats in a particular way because you were thinking about this hypothesis.

Oh, yes, I was always looking for evidence. I mean that's why I went down and collected the seaweed. I was looking for elements that were being emitted from the ocean, and later went on a long sea voyage to see if it was not just local, it was global. And, I did that, but, you soon come to the end of that. And it was very frustrating, I mean you could wander around, and, you really couldn't pick on anything. The problem is, I think, a global phenomenon, and there is a global phenomenon, and, you, if you really want to look at the Earth, you've got to look at it from outside, from the top down. If you try looking at it locally, you, you don't get very far.

Mm.

And, so, this side of it was a bit frustrating. And that was why the whole Gaia set of ideas were a bit slow in developing. I think a thing, I must interject here, I was not some scientist who had private means and can spend all my time looking at doing Gaia research. I had to earn a living. And I was earning a living by having about six or seven different customers. I knew I had to have that because, if I had only one or two customers, it would be just like being employed. I would be then sort of, tied to one single thing, and I didn't want that in any circumstances. The customers, now just to enumerate them, that I had during that crucial Gaia time were, JPL, who paid me a consultancy retainer, it wasn't all that large, I think it was $6,000 a year, but soon I became for JPL a contractor and would build instruments for them, and it upped to about $20,000 a year, which was much, much more effective. There was Shell, which was paying me a retainer, not a very big one, about £2,000 a year. There

was Pye before it was taken over by Philips that was paying about £2,000 also. And, there was the Ministry of Defence, that was the MI5 work. I think that was about all. That was quite enough all together at that time. And, so, they were all presenting problems that required solution. So, in a way Gaia was very much a part-time job.

[25:12]
Mm. Now one of the things you were doing at this time is, the work on ozone for example. What did, what did your experience of measuring CFCs for example contribute to your thinking about Gaia?

Oh quite a lot in a way. It was a global measurement, you see, again, it justified a journey, a sea journey to Antarctica and back, and measurements on the way of Gaia components, like the dimethyl sulphide and methyl iodide and things like that. It also gave me a personal view of the world. I mean there were all sorts of things. I remember so vividly as the ship was travelling southwards, the mate who I got to know very well, Nigel Jonas, he would come round and say to us, 'Hey, look you chaps, you'd better start getting some sun block, we've got plenty in the stores. You can't go around in shorts and open-neck shirts on the deck like this as we approach the Equator. You'll get a terrible attack of sunburn.' But they sort of, said, 'Ah, never... didn't get sunburnt yesterday, and the sun was shining, I won't get sunburnt tomorrow.' They didn't bother. And, so it was. And then, suddenly one night somewhere well south of Dakar, in Africa, the ship crossed the Intertropical convergence, that is the atmospheric wall that, that people now don't really know... most people don't know of its existence. I think it coincides roughly with the Doldrums, that sailors used to know about.

Mm.

We crossed that, that region, and entered the Southern Hemispheric air mass. Now the Southern Hemispheric air is free of pollution. There's no great industries, no people much down there, it's far less than in the North. So the air is sparklingly clear. I went out, as I always did, quite early in the morning, and got my air samples, and I noticed that just, during, taking the air sample, the sun beating on my leg felt very hot. Not just the heat of the sun, but I could feel slight burning. I thought, aha! we're

getting the UV coming through in spades down here. And from then on, oh, there was the most frightful epidemic of sunburn amongst the people. Because the air in the South is so much clearer. And it made me realise what a polluted hemisphere we do live in up here. And it was a kind of Gaian thing in a way, there was a global thing, two halves of the atmosphere, how different they were.

Mm. Thank you.

It was very beautiful too. You could see cloud streaks going far into the distance. Whereas in the North it's always hazed up.

[27:55]
Mm. Thank you. Could you tell me about the effect of your work with particular collaborators, and, I'm thinking in particular two female collaborators, Dian Hitchcock and Lynn Margulis, am I saying that right?

Sure. Mm.

Could you take each of those in turn and indicate the importance of those relationships on the development of the theory?

I think, in many ways, although Dian Hitchcock had almost nothing to do with Gaia theory, I didn't much, I didn't... well I hadn't formulated it when I first met her. I first met her in, at JPL, at the time that I went to see those biologists.

Mm.

She had been sent down with an assistant, Gordon, I think Gordon Thomas I think his name, by NASA, as a kind of auditor of the worthiness of the experiments that were being sent to Mars. It was an interesting thing that the NASA administration did. They were a pretty good lot in those early days, because there weren't many and they were very bright people running the whole thing. They thought the quality of the experiments that were going to be sent, because they're pretty expensive, should be judged by sending down somebody who was very good at sussing out the, the logic of

the... She was a, a first-class philosopher of the type, you really have to watch every sentence you make, because she was so sharp. And, she went around and interviewed all of the experimenters that would do... and was pretty disgusted with most of it. But, she and Gordon Thomas were both, at least they said, deeply impressed with my suggestion of an entropy reduction life detection experiment. And she was a very strong supporter, and I think was instrumental in arranging the NASA invitation to come to headquarters and discuss the idea with them there.

Mm.

And, I think, had that particular experiment... sorry, mission, the Voyager mission it was called then, gone ahead, she would have played a very big part in it, and probably I would deferred to her, passed over to her to manage it, because I didn't, not my scene, managing those kind of things.

Mm.

And, so, she had a great deal of... And, with her help, she refined a lot of my ideas about the atmospheric life detection experiment, she was a person who could see through the logic of everything, and I think she helped my mental education more than I really care to say. She was a person of extraordinary intelligence, I think one of the most intelligent people I've ever met, but she was not particularly creative. I mean that was my role in the thing.

Mm.

I would say I'm quite creative but not all that intelligent.

[31:00]
In what ways did she refine your thinking? Would you be able to give an example, or is it much more of a diffuse influence?

I think if you, if you, anybody who wanted to find out, if they read the paper that we jointly wrote together, and it was a joint writing, because, I would do some sentences

and then she would correct them, and, we would come to an agreement on them. And that was when each step... If you compare that with my other one which I wrote on my own, the first one, 'A Physical Basis for Life Detection Experiments', anybody who was competent would see the difference, how the ideas had been cleared up and presented in a much more logical way.

Where did you write and discuss together?

Oh, all sorts of, various places. JPL quite a bit, at her house in Hartford, Connecticut, and, sometimes she came over to Bowerchalke and worked with me there.

[32:05]
Thank you. And Lynn Margulis, your, the effect...

She came in a bit later. I've forgotten... I cannot royally pin down the exact date, but it was quite some time after that epiphany at, at Jet Propulsion Laboratories. She was married to Carl Sagan primarily but by then they were divorced. But her first two children were, were with Carl. And anyway, somewhere it would have been... Let me see, I'm trying to think when. Probably early Seventies, I got a letter from Lynn asking me if, if I would... she... if I had any views on the appearance of oxygen in the atmosphere and what, you know, its role. And she said she she'd spoken to Carl about this and he said, 'Oh the person to speak to, if you want to know about that, is Jim Lovelock, because he's interested in the atmosphere and its origins.' And, anyway, I got this invitation to drop in on her lab. She was at Boston University at that time. And I did. And... She's a very lively person, and we discussed it animatedly. But she badly needed, I think... Well I mustn't... can you cut that? I mustn't really say that, anything negative about people. I think we could both have done with Dian Hitchcock around at the time to sort out the logic of, of the way we presented the, the initial ideas on Gaia. And, I think, it was wonderfully helpful as a relationship, because, she was, brought in the concept that the real infrastructure of the Earth's system are not the large things, the trees and the animals, food bacteria and microorganisms generally, and that I think was a most important contribution, and one that people failed to, to keep in mind all the time there, what keep the whole show going.

Mm.

And, she was exceedingly good at that, and she would be quite, how can I say, angry at the thought that bacteriology was always taught as a medical subject instead... Because the, the pathological organisms are a tiny sub-fraction of a huge range of organisms performing all sorts of roles around the Earth's environment. And that was, she was the right sort of biologist to be involved in the whole thing at that time. [34:44]
But Lynn was a very combative person, and she maddened the other biologists an awful lot, [laughs] and didn't help my relationships with them either.

Mm.

And, there was an article in *Science* towards the end of the Seventies which referred to Lynn as, what was it? 'science's unruly earth mother'. And was really, most horribly disparaging, almost libellous, of her. And she was distraught, because, she thought all her grants would be shut off, she would lose it, her reputation. So I wrote a response to *Science* saying how unfair this was and how, that was she was, that she... it was most improper to criticise a scientist that way, just because you disagree with them.

Mm.

And, it got published, so I hope it helped.

Mm, yes I, I...

But, but she did sort of, [laughs] without really meaning to, stir up that kind of, of problem.

[leafing through material] Would this have been the, your response I think?

May have been, yes, there you go. That's right. [pause] [laughs] Yes, the Kitty Kelley school of science. [pause] Yes. No, anyway, that says what I thought, and I hope it did the job. I think it did.

Could you...

I'm surprised you found that.

[36:10]
Could you paint a picture of your working relationship with Lynn, in terms of...

Exciting would be the word. [laughs]

But, but, I guess the places where you worked. So, I know that you, you not only worked on discussing and writing in rooms, but also walk together?

That's right.

And so you went...

All, all over.

So, I wonder whether you could give me a sense of...

We went on expeditions together even.

Mm. Could you give me a sense of the way in which ideas were developed in that way in the field?

Yes. [pause] This is not... Well one of the places we went to in the field was Baja California. Lynn organised an expedition, I don't know where she got the funds from, but, that's neither here nor there. And, a small party of us made a trip right the way down to the Laguna Figueroa I think it is, halfway down the peninsular of Baja California in Mexico. And, we stayed at a tiny Mexican hotel just by the coast there

where the lagoon was. And to my amazement, because, in America I had been taken to Mexican restaurants once or twice and I did... and I hated Mexican food, it smelt to me like fried horseshit, [laughs] if I can put it... But the food at this place was heavenly. It was fresh fish from the sea, all sorts of good stuff. So, just shows you should never judge a country's cuisine by the, [laughs] the restaurants in another country, alleging to be Mexican. But, that's entirely aside. At this Laguna Figueroa, it was an evaporite lagoon, which is one of the important things about the Gaian regulation that Lynn kept on about but I was a little bit less excited about. I think I started it by wondering about the salinity of the sea. You see my freezing work many years previously at Mill Hill had told me that organisms of any kind cannot stand salinities above .8 molar. They die almost instantly, within a fraction of a second, when exposed to it. So, the sea is .6. It's not far off the critical point. So, what was regulating the ocean salinity in, just at the upper safe limit? And, try as we might, we couldn't think of any way of doing it. But we knew where the salt went, it's continuously pouring into the ocean, down the rivers, off the land as new rocks are exposed. But, where does it go? And the answer was, to evaporite beds. Now these are great lagoons that form along the side of the continents in the warmer parts of the world, and I had wondered very much whether the Great Barrier Reef in Australia is the initiating process of, a gigantic evaporite lagoon that is going to form down in that part of the world. May not be at all... it's pure speculation. But anyway, these evaporite lagoons do form, and the sea water goes into them, and evaporates and you get the salt that deposits at the bottom, and gradually it fills up the lagoon and it becomes a salt bed. And, under Europe for example, there are huge layers. I've been down to salt mines in Cheshire, and, they're about 400 feet below the surface. And then there's hundreds of feet of pure salt, and it goes all the way, right out to Russia, under Europe. It's a giant, a giant evaporite bed that existed long, long ago, the salt, salt mines of Poland and places like that are all part of the same evaporite bed.

[40:15]
When did you first discover that...

What?

...evaporite bed, beneath Europe, in terms of...?

[laughs] I was first taken down there by ICI in the CFC ozone affair. Because we wondered if any halocarbons were coming from all that salt. It's all chlorine. [laughs]

Mm.

There weren't any. But it was worth going down to try and find out.

Mm.

And...

[40:36]
And so, your... this particular excursion with Lynn Margulis to these salt beds, could you... Arriving there, confronted with these salt beds and the vegetation, can you describe what you did as scientists to examine them?

Oh yes, she was examining all the microorganisms on the surface. And one of the most interesting things she found, which I think was very Gaian and very important to the thing, was that there's, the, the salt when it evaporated formed big cubic crystals, and on the surface of the crystals, organisms had deposited a varnish, which made them water-resistant.

Mm.

And, so that when the rain came, instead of the evaporite bed going back into the ocean, dissolved, which you would have thought it would have done, it wouldn't, because of the, this varnish stopped the water getting at the salt. Now this I thought was quite a discovery. And, it was things like that, of the role of the microorganisms in sort of stabilising the removal process, and, there was a lot of that. And I think that was the way that we reacted most effectively collaboratively.

[41:52]

Standing there and, and seeing Lynn doing science in that way, can you describe how, how she studied, I mean how for example she discovered this layer on the, on the crystals, did she have equipment with her, how did she sort of approach this landscape in order...?

I, I can't tell you that.

Mm.

All I know is, we went out there, and examined it. She had a pocket microscope she took along with her and looked at the things. And, she took lots of samples and took 'em back. And of course Boston was full of science people who could further examine them and report on them and whatnot.

Mm.

I was more of a kind of observing collaborator on that particular expedition, and she was the one that was doing the work. And, and her colleagues and students who were all along there.

[42:47]
Mm. If I can just advance a wild theory and you say whether you think there's anything in it.

Mm.

Dian Hitchcock and Lynn Margulis seem to be two fairly important people in the development of Gaia, and I realise there are others. And, is there anything in their femaleness that is important in, in the success of that collaboration, particularly as we've, we've spoken a little about perhaps an American academic culture having aspects of, what you might see as maybe extreme masculinity with the kind of sportiness of someone like Sherry Rowland for example.

Yes.

I wondered whether there was anything in the femaleness of these collaborators that was part of the reason why it was successful in your case.

Good try Paul. [laughs] I don't think it, it really had a great deal to do with it.

Mm.

Because both Dian and Lynn were pretty tough characters, and exhibited much of that same kind of thing. Lynn was very very political, almost invariably on the, on, on the Left. She would have, I don't know... I've seen her recently, but I don't think conversation got around to it, but I would imagine she would have thought that Bush was the work of the Devil, you know, he was a lightning conductor for all sorts of bad things. [laughs]

Mm.

So I think she was the person... I, I'd learnt, because both of them resembled my mother, as exceedingly strong, forthright, argumentative women who, who you, the sensible thing to do was to be fairly quiet and agree with them, but go your own way. [laughs]

Mm.

And that worked, it, it worked well with them. As it did with Audrey Smith, another female collaborator, that I had at, at Mill Hill. I think the fact that they were female was purely coincidental. It wasn't any deliberate choice on my part, either of them. They entered my orbit and sort of, circled for a few revolutions and then moved off on their, on other things. There was no, it wasn't, nothing, there was no bad, there was no break-ups or great fusses. Except... It was interesting that early in the relationship with Lynn, when I used to go along and stay with her in Boston when I came, she took me to the airport once and she said, 'I've got to sort of, make it clear on the ground rules. There's nothing in our relationship other than scientific.' And I said,

'Oh you don't need... I'd never thought of it any other way.' But that, that... And there wasn't.

[45:40]
Mm. Could you comment on the particular difficulties for women in science at this time? Part of the challenge that we're facing as a project is in, part of the remit is to examine the role of women in science, and, it's actually quite difficult to find women in science in this period in terms of British science. And I wondered whether, we're talking about a really American science of the same period at this time, whether there were particular difficulties faced by Lynn and, and Dian Hitchcock and others in becoming and remaining scientists at this time.

You should have asked me that question vis-à-vis women at Mill Hill.

Mm.

Because I had quite close connections with, with several of the women, as well as the men. I was totally, how can I say, I won't say sex blind, because that would be grossly untrue, but I was not sexist in any, any sort of sense whatsoever. Whether that was being brought up by my, a mother of the type that I had, feminist mother, or what, I have no idea. But I regarded scientists I worked with as colleagues, and if they were female, it's neither nor there. I think had they been astonishingly attractive and young... Oh yes, no, I even had that happen. When I was at Harvard Hospital, and I developed the ionisation anemometer, I had as a graduate student an exceedingly attractive young, young woman called, she was then Ricki Croft, she married a Pole called Wasilewska, and that became her name later. But she was extraordinarily attractive. But it didn't, in no way did it affect our scientific relationship, or, or did I feel I'd like to go off and spend a dirty weekend with her. You see it wasn't... Somehow, science always seemed separate. And I treated her as another colleague.

Mm.

And that was all there was to it.

[47:38]

I don't find that difficult to accept at all in your case, but I wondered whether just, the general world of science made it difficult for women at the time in certain ways, not that you would have done personally, but that...

I think the feminists are all wrong on this one. And I think I speak from good experience. We had a woman scientist at Mill Hill for example, Ros Pitt-Rivers, who, she became an FRS, she's quite famous in the work she did on, she started off working with Harrington but went independent later, on thyroid hormones and thyroid diseases and so on. Very famous woman scientist. But an utterly balanced, likeable person, she... and, very human, very motherly, very nice. Also quite good-looking. The absolute antithesis of Audrey Smith, [laughs] who wouldn't have fitted in in any environment, male or female. And, it, it... I don't think you can generalise about these things. For various societal reasons, women, certainly in the early days, didn't go in for science, and they didn't want to, they weren't interested in it, it wasn't what turned them on.

Mm.

And, if they did go in for science, they almost always became biologists.

What do you think those societal reasons are that selected against women, self-select, they were self-selecting against?

I think... Well, to start with, back then schools were separate weren't they, girls were taught separately.

Mm.

I think the whole teaching procedure was such as to be inimical to the kind of scientists for example that I became. I don't think it would have... The, the... Not only that, but there's the peer... You see, I think in education, peer groups are

infinitely more important than teachers, and, a group of girls together is a, a wholly different kind of peer group than, than young males together.

Mm.

And I don't think girls have that kind of incentive, of wanting to make weapons, [laughs] for example, which boys will, of any kind. They, they don't naturally want to go and make their own bows and arrows, which they did in my age group, or, or, try out guns and things. A few will, admittedly, but, the great bulk don't. And, I think it's peer group influence is much more important in moving you into a direction you become later in life. And, that, that plays a large part in it.

Mm.

But I'm not an expert on this, and you shouldn't really ask me, because I don't think... my scientific life, which certainly mixed with more women colleagues than most scientists, but I think that was purely accidental, that was the way the cookie crumbled.

Yes.

[End of Track 12]

[Track 13]

Could you please talk about the importance for the development of Gaian theory, and perhaps this will overlap with the importance for your scientific work generally, in the use of computers. Now, you seem to be quite interesting as a person as someone who used the sort of computer that might fit on a desk early.

Mm.

Within the project we will encounter people who have worked with these very big machines, the sort of stuff that you would send data to for processing and get a response back. But you seem to be quite ahead of your time as someone who used a computer in a much more routine way as part of your work, in the way that people think of using a computer now routinely, something on their desk, something they work with. From your very first purchase of a, what might be called now a home computer, could you talk about the importance of it for the development of Gaia and your work generally?

Well my first, the first computer I produced which... purchased, is, I think now at the British Library, Jeremy took it. It was, it had broken down over the years. But, it wasn't really very much more a computer than a pocket calculator is nowadays. It was certainly a lot easier to handle, it was a desktop one. And, it was made by Hewlett-Packard and that firm was in its heyday then. It was beautifully made. And the manuals that came with it were a delight to read. I got to meet the manual writer and many of HP's things later on, she was a woman called Rosemary Buffington, and she was so intelligent and literate. I mean, the computer manual was illustrated with quotations from *The Hunting of the Snark*, which gives you a kind of, illustration of its quality. Oh it was so wonderful. And so, it didn't take me long to understand how to use it, in, in the way a computer should be used. And its language was a form of assembly in effect, a little bit better than binary but not much. And, I had the problem of solving the differential equation, getting the solution of the differential equations for the electron capture detector and doing it by what's called numerical analysis. And this simple desktop thing was fine for the job. And you could... It even, Hewlett-Packard had even provided a plotter that went with it. It was a, a peculiar

plotter by current standards. It had two arms and a pen attached and it would, you put a sheet of paper on a platen and it would then draw the graphs. And it, fascinatingly it could write in the letters too, the pen sort of, robot writing for the labelling of the axes and things. So, I was able to get all I wanted to know about the ECD of how it worked. And I became then, it was almost an uplift for my mind, this was round about 1970, in that, ah, mathematics is no longer a fearsome thing that is holding up my progress in science. Now I can handle stuff that even the, the senior wranglers couldn't handle a little while ago, because a computer will do it for me. And I think as a celebrated mathematician, Euler once said, all operations of mathematics can be reduced to simple addition and subtraction. And of course that is true.

Mm.

And, you don't want ever to be bamboozled by it. And that sort of made that leap, that enabled me to, to handle maths.
[04:03]
So many years later, when Richard Dawkins famously said that, you know, Gaia's a lot of nonsense, it can't possibly be, because there's no way for an organism to regulate anything beyond its body, its phenotype, and, I expect you can talk about a bees' nest as something slight... but it's not really, it doesn't really count, you certainly couldn't be regulating the world. And it was a pretty devastating criticism. And he was... of course he was really voicing very much senior biologists like, William Hamilton, Robert May, and, John Maynard Smith, who all held the same kind of view. In fact John Maynard Smith held the very strong view that Gaia was just an evil religion, it was not science at all. I mean that's pretty severe criticism. Anyway, I'd got to find an answer to that mob.
[04:59]
And, I thought about it hard for a year and it suddenly dawned on me, the only way was to make a mathematical model and demonstrate the mathematical basis of it. And in Christmas 1981 I sat down in front of a much more developed HP computer, this one was a 9845, which was programmed in Hewlett-Packard BASIC, which was an engineering program. It wasn't a kid's stuff BASIC. I mean it was really, a proper computing language. And I easily programmed it. And, I could wonderfully interact with a computer, and, sort of, almost like you, you do a word processor, and it evolves

the program as I sat there. And, to my delight it worked first time, it just, there was this wonderful stable thing. As the sun warmed up, so the temperature stayed absolutely constant as these two daisy species evolved together. And that was the absolute answer, and it still is, to that, that criticism of how, how can a whole planet regulate itself by natural selection? Quite simple, if you look at it as a whole system and not just as individuals.

Mm.

And, it's been argued about, but nobody's falsified it, and I don't think they ever will.

[06:21]
And presumably, you programmed that here, did you, where we're...?

I programmed it, my computer was in the other room, yes. And it didn't stop there. I mean the first thing... The biologists hated it, right from the very beginning, they loathed it, because they couldn't deal with it. Most of them are not programmers anyway. And, they just didn't know how to... Then they suddenly all agreed, ah, I know what'll kill it, cheats. If you put a cheat in it, a daisy that didn't change anything, the climate or whatnot, it would take over the whole planet and that would be it. So I put a cheat in, I put a grey coloured daisy in, that, that... and then taxed the dark and light ones five per cent, the growth factor for, to pay for making pigment.

Mm.

And it just went exactly smoothly and perfectly. And it was so obvious. You could explain it in words, which irritated the biologists even more. It's only when it's cold that the black daisies are fit to grow. Because white ones couldn't when it's cold, they'd just get colder. And it's only when it's hot that the white daisies are fit to grow. The grey coloured ones only grow when regulation is not needed in the middle. And that's what happened, and the model. And, eventually finished up making models with hundreds of daisies, of plants, not daisies necessarily, all sorts of herbivores grazing them, and several predators, three trophic levels, the whole damn thing. And they did, the models just purred, were stable as blazes.

Mm.

And of course I was unaware then that this was solving in some ways not only biological problems and Gaian problems, but also, it was kind of hinting at things like the three-body problem of mathematics, you, you... which of course is, you cannot compute the orbits of three gravitationally connected bodies in space, because it goes chaotic.

Mm.

Any, any system of more than two differential equations tends to go chaotic. And that applies in, with obits of planets, it applies to air motion in the Lorentz equations, and it applies in biology as Robert Mayer has shown. But Daisyworld, none of that happens, it's as stable as a rock.

[08:46]
Mm. Why daisies in the first place, why did you pick daisies as opposed to any other flower?

I... If I were religious I would say it was sent. I was about to program, do my program, and I thought, well now what, what... I've got to have plants involved here; what one shall I choose? And there fell open on my desk the latest copy of *Nature*, and there in, [laughs] on my desk in front of me, was a paper by Carter and Prince I think it was, on the area competition and spread of plants in Devonshire, and these were a form of plantain that grew in the open, and they, they competed for, for space. And they were all the biological equations I needed. And I suddenly thought, well if they weren't plantains, they were daisies, and there were two different reflectivities, that would be the way to do it. And it all came together in a flash, and it was very easy to write the program from then on.

[09:52]
And later, when, I can see it on the shelf there, could you tell me about the meeting with the programmer which involved you in the SimEarth computer game?

Oh yes. Ah that was wonderful. Daisyworld sort of spread around underground, it was condemned heartily by biologists but not, most other scientists were neutral about it. And, it must have got to the game programmer, Will Wright, because he's sort of, the king of that game stuff now, produced SimEarth and the Sims and all... SimCity and the Sims, and so on. And it was a joy to have him come over here and spend a week with me going through the program of Daisyworld, to see how he could use it to form the basis of a SimEarth that people could play with.

Mm.

And, I learnt an awful lot about programming from him. I remember him going through the lines of the program for Daisyworld, and he said, 'What on earth are you using an exponential function for?' And I said, 'Well what would you use?' He said, 'I'd just use a binary shift. An exponential function will cost you fifty-six bits,' he said, 'but a binary shift is just one bit.' [laughs] So, I mean, it was the way, the games programmers are kings in, in making economic something practical that will really, really work.

Compressing.

Yes. Oh he was wonderful to work with.

[11:21]
And could you talk about, over this whole period from the early Seventies to now, the... particularly the early period though, the use of the computer in a more mundane, routine way as part of the practice of being an independent scientist? I'm thinking, not merely of sort of, mathematical calculations and programming, but the use of it more as a sort of day-to-day tool?

Well more than... Perhaps the most exciting example I had, which, really it's another one of those great moments in life, was, I used to spend an awful lot of time in the old days, for example before the *Shackleton* thing, soldering together circuit boards to join up all sorts of components and things. And then I heard about, because of my

contacts with HP, which was way advanced in those days, about software electronics. My mind lit up, software electronics, what's that? And they said, 'Oh well, when you think about it, a computer's just a mass of transistors and things. You've got... there's no need at all to go soldering things, joining them up. You can just write the, the program, to do the same thing.' And I had had, spent hours making low-pass and high-pass filters for my bits of instrumentation. And I sat down in front of a simple old HP computer that I had on the bench... or, sorry, on my desk in Bowerchalke, and just wrote, I should think about, can't have been more than ten lines of program, that did all that it had taken me hours to do wiring up this... perfectly. And easily adjustable, so that it would, the signal just had to be passed through that program, and you could filter it, do anything you like. And of course, most of the things they now sell as radios, it's all software electronics, there's no, no hardwiring going on anywhere. The chip does it all.

Mm.

[laughs] It's incredible.

Yes.

And it was such a revelation to discover that you could do that.

[13:20]
When did you first use it as a way of just word processing and communicating with other scientists and, as a tool?

I think I used the first word processors in Britain. We got an IBM, what was it called, something typewriter. It... [pause] I can't remember the exact description of it. But it was an IBM typewriter that had a, a rudimentary computer software built into it, so that, what you typed would be stored on, I think it was a magnetic disc, and you could store up to, I think it was twenty files that could contain several letters each. And it would then, if you called up the file, it would print it out on your computer, on the, the typewriter section of it with a, you know, a computer-operated printer. And, you... Or you could print as you went. But it also enabled you to correct. You could correct

errors and things like that, and... It was, it was a rudimentary word processor, and all my first papers and stuff were done using that. As soon as the very first word processors became available, the one I first used was called Wordwise, that was a, a software add-in that you could put into the early Hewlett-Packard computers, the desktop computers, and they were so damn good. It was written in HP BASIC, the whole program, so that you could dive into the word processing program and alter it to suit yourself, which is something you can't do with any of the modern ones. It did everything. It had a spell-checker, everything, there was a grammar checker came with it. All of the things that a fanciful, Word or WordPerfect did, it could do. And, I used that until those actual computers became so expensive to buy, compared with an IBM thing, that I had no option but to downgrade and go along with Word and WordPerfect and those sorts of things.

[15:37]
Mm. Thank you. Could I ask you now about conferences, and I think, one way to do this might be to compare the success of your Oxford conferences, which I know were funded, as you told me yesterday, by...

Yes, Knut Kloster, yes.

Yes. Compare those, which I know... which I, I suspect or seem to suspect were in some way inspired by the Gordon Conferences that you had been to in the schools in America.

They were a bit. Yes, they were.

But, I wonder whether you could compare the success of those with the San Diego, 1988, American Geophysical Union Conference, in terms of the conference as a, as a kind of performance, a place where you can develop but also display scientific ideas, and in this case a new theory. So I wondered if you could compare, I'm asking quite a lot really, but I wonder if you could compare the Oxford conferences with, in particular, this conference that I know you weren't happy with, in terms of the different...

Yes, that was 1988, and, the first Oxford conference was 1994, that's six years later. So, time had changed quite a bit over that time. Now that first conference was organised by Steve Schneider, the famous climatologist in America, who's a good friend, and, he, I've never known whether he was a supporter of Gaia or against it. The only recollection I have that would tell me either way really, because he always kept it very close to the chest, was, once I was at a meeting at NCAR, the National Center for Atmospheric Research, and a very heavy geophysicist was saying, 'Ah, this Gaia business, just the most raging nonsense. New Age crap.' And Steve turned to him and said, 'Could you write a program like Daisyworld?' and then explained what Daisyworld was. And it was kind of collapse of stout party, kind of thing, straight away. So I thought, well, Steve must be on side to quite a, an extent, and he knew all about the program and whatnot. But, the pressure against Gaia was enormous in America, and still is. The, *The Revenge of Gaia* was written, when was it, just about two or three years ago. The American scientists' review of it by their chief leading science editor referred to the book as 'great balls of Gaia'.

Mm.

And, the whole tone of the review was in that, that, that, you know, New Age rubbish, we don't want any part of it.

[18:27]
Mm. Why in America you think that that is persisting, that...?

Because it's Germanic science, America, it runs on the old Germanic style. The Herr Professor is lord, and the graduate students are his slaves, they have to do his bidding. And it's very very hierarchical.

Mm.

At least that's the impression I get of American science. It certainly was the way it was done at Harvard when I was at Harvard Medical, and it was quite a shock after the incredibly liberal atmosphere of, of Mill Hill. And, I remember graduate students were appallingly badly treated, and, the general reaction was, 'Oh well, when I

become a professor I can do the same with the slaves that are given to me.' And they almost enjoy doing it, and expect the slaves to put up with it. And this is a tradition I think that came in with the German scientists who came in and sort of started the university science in America, and it's gone on till... It's also very macho and dogmatic, and they won't change things. [pause] It's difficult to explain really. And I may have got it wrong, it may be a prejudiced view that has come from...
[19:45]
You see, when I first went to America as a freezing expert, I was welcomed everywhere, I could practically write my ticket all round the country, and offered incredible jobs, enormous increases of salary, which I didn't want. That was how they took it. The same was true with detectors and gas chromatography, again, I mean there was sort of, marvellous spontaneous welcome. You were the sort of star figure at a conference or anything like that without any trouble. Gaia, no, I mean, [laughs] you had trouble getting in, in past the guards at the entrance.

Mm.

It's... So it's not personal. It's the subject that is, frightens them.

[20:36]
Mm. Then if we, if we can think of the Oxford conferences, could you explain how they were organised in such a way as to...

To be different.

To be different, yes.

Yah. Well, we wanted everybody represented that had a view. It didn't matter if it was completely contrary; we wanted their views expressed, and we wanted, as... we wanted the conference to give lots of time for discussion amongst the members. Because I think, I learnt early on that all good conferences, the important stuff is discussed in the corridor, in the quiet times. The papers don't really get you very far. And you shouldn't stuff a conference full of people chatting, talking, because, there isn't room for all the other interaction. It's the other interaction that's important. So

the papers we asked for from people were intended to be entertaining, uncontroversial, that sort of thing. And also we'd be choosy about speakers. We wouldn't, wouldn't choose a dull speaker. And, and we wouldn't choose somebody too argumentative. Perhaps wrongly, we didn't choose to ask Richard Dawkins to come; maybe he wouldn't have come, but we didn't ask him in those conferences, because he was such a, a combatative debater, do you know what I mean? It wasn't the atmosphere we wanted; we wanted something a bit more constructive. But we didn't mind in the least asking people like John Maynard Smith or Bill Hamilton to come along, who were just as anti as Richard but much more intellectual and able to express their view that way.

[22:19]
Mm. Could I pick up on what you said, which I was very interested in, that, the good stuff is discussed in the corridor, the interactions between the papers.

Yes.

Would you be able to give an example of how that is true, how that is the case?

Oh it would be hard to remember a particular example of that. But, I think if you talk to almost any scientist anywhere, not only scientists but politicians or anybody, they would say the public meetings and the speeches and things are one thing, but the decisions are made in the corridor afterwards, amongst one or two people. I think one thing you learn in human life is that the committee, the chattering group, are there really as cannon fodder. I learnt when I became President of the Marine Biology Laboratory here down at Plymouth, I always wondered why I ever became, why they chose me, but anyway they did, I learnt very rapidly on that the committees that, that were gathered to decide what to do, [laughs] you the president and two of your cronies, who were powerful people in the system, decided beforehand exactly what the agenda was, how it would be pushed through, and who to neutralise and how to do it. You went through all the motions, and they all said their pieces and thought they'd, you know, made a point, but, it had no relevance to what the decision was going to be.

Mm.

And that was already predetermined. And that's how life goes on. So it's in the corridor, when the one or two get together, that the things are decided, not in the big chattering, open thing that...

[24:00]
Well these conferences were very successful in establishing Gaia as a scientific theory...

That was their objective.

...accepted in Britain.

That's right.

Could you think of any key moments beyond the delivery of papers where you think decisions were made or causes advanced that actually meant by the end you could say that this has been important in establishing Gaia as a scientific thing?

Well interestingly, I felt, and Sandy felt, that we shouldn't intervene too much. Everybody knew what our position was. And, we left them to gather together in the in betweens and afterwards, without being even present.

Mm.

But that it worked was only too clear.

What was the, what was the noticeable effect for you after the conference then?

Well, I mean, the total change in attitude of some of the participants. John Maynard Smith was a classic case, because he wore his emotions and his heart on his sleeve much more than many others did, and, to swing from referring to Gaia as an evil

religion, to coming along to the meeting, and correcting people who had got Daisyworld wrong. I mean it was an enormous changeover. So, it worked.

[25:20]
Mm. Thank you. Now, as you mentioned Sandy, it would be a good time to, for you to comment if you could on the importance or effect of, of Sandy's role in the development of Gaia and the promotion of Gaia especially.

Well it's been enormous, I think, that, Sandy did a lot of things for me. Before I married her, and partly I... it's a matter of upbringing and all the rest of it, I, I always seem to have very low self-esteem, and, that was one of the reasons I worked on my own I think as much as anything. I, [laughs] I didn't, didn't think I could hold down a professorship or something like that, it would be beyond me. Not that I particularly wanted one. But, but, she has given me the confidence that I, I lacked otherwise. And not in a kind of fulsome or silly way, but, just made me take some of my own thoughts a bit more seriously than I had previously. So she's fulfilled that role. And I don't think anybody who's not had a really true, successful relationship, knows beforehand just how good it is. It has to happen. And we've been married now twenty-two years and it's been wonderful, it's been incredible, and the rest of my life, I wouldn't call it a wasteland, but by comparison it was.

[26:54]
Aside from making you very happy and for increasing your self-confidence in your own ideas, is there a, are there particular roles that Sandy takes in promoting Gaia?

Nothing that's ever organised, it just kind of happened. And, Sandy feels so much a part of it as do I, and our lives move, move in that sort of way. We don't do a lot of things separately.

Mm. Yes. And so, is Sandy a collaborator in terms of thinking about Gaia as well as...?

Yes. We talk, talk in bed in the mornings and on walks and things an awful lot, ideas, share in the idea development.

[27:43]
Thank you. Could you talk about the meeting with Crispin Tickell from 1988 and the effect on that in the promotion of...?

Well it happened much earlier than that. Crispin Tickell was chef de cabinet for Roy Jenkins when he was President of Europe for a brief time, you know the rotating presidency.

Mm. Yes.

And... In Brussels. And that was in 1979, and that was the year my first book, *Gaia: a New Look at Life on Earth*, was published. Crispin bought a copy and liked it very much, and wrote to me straight away, and, we established a contact, not very much, because he was exceedingly busy for, became Ambassador at the UN as you know for the UK, which must have been a pretty tough job, and that was during the first Iraq war.

Mm.

And... Anyway, we made occasional contacts but nothing very much. And then, in the mid-Eighties I was asked by the Commonwealth Foundation to write the book *The Ages of Gaia*, which is not... it's an interesting one, that, because that book was, it was a peer reviewed book. It's not often a book is peer reviewed.

Mm.

And it was, the earth scientist who peer reviewed it was none less than Dick Holland, the professor of geology at Harvard, and a strong opponent of Gaia.

Mm.

The biologist was Lynn Margulis of course which was on the plus side; the literary side of it was reviewed by Lewis Thomas himself, and by also Lady Medawar. So, it

was properly peer reviewed. It had to be, because the Commonwealth Fund insisted that the book was peer reviewed before they would support its publication.

Mm.

[29:39]
So, that, that was the thing. Now, scientists won't quote it. American scientists won't quote it at all, because it's not peer reviewed, they say.

Hm.

And, they don't ever quote non-peer reviewed literature. Only literature that's peer reviewed can be quoted in America. And, they're quite rigid, and again, Germanic about this kind of thing, it's a rule so you don't break it. But nothing stops them mining the book for ideas, and publishing them under their own name, which they've done extensively.

Are there particular examples of that that you can...?

Well I'm not going to go into names, because I don't think it's appropriate in a thing like this, but anybody who, who wants to read *The Ages of Gaia* and then look at the literature afterwards, will soon see.

Yes.

I mean there are some pretty obvious cases where for example, in that book, *The Ages of Gaia*, I, I think I was by far the first ever to suggest that the atmosphere of the Archaean period of the Earth, that's between 2.2 billion and about, soon after the origins of life, the Earth had an atmosphere dominated by methane as the gas. There are models in the book showing the probable level of methane at about 100 parts per million; there would have been traces of oxygen also present. This would have given the right greenhouse to keep the Earth warm with a cooler Sun. There was also the methane equivalent of an ozone layer, decomposition products of methane floating in the, now what was it?

The, the methane and the...

Oh that's right, yes, there was, the methane decomposition product formed a UV, opaque layer in the stratosphere. More important than that, because they were absorbing the UV, it kept the stratosphere warm relative to the troposphere and put the lid of the inversion. So the methane then didn't have to cycle up in large quantities into the upper atmosphere and be destroyed by solar ultraviolet. And it could build up to inform its greenhouse down below. And, I then argued why in the model, that state of affairs persisted for about, nearly two billion years before oxygen appeared and took over as the dominant gas, simply because the early Earth was much more tectonic than the Earth is now, and the rate of turnover of plates was something like three and a half to four times faster than it is now, and, therefore, lots of reducing matter that will remove oxygen were being continuously produced from below the, the sea. And, that kept the Earth in a reducing state and allowed the methane atmosphere to be...
[32:30]
Anyway, it was a very valid model. And, as I said, it was, you know, mathematically modelled, everything was there. But they just stole the whole bloody lot and never, with no, no reference to the book.

Mm.

Not only... What makes me quite sad is, that was not only done by the Americans, who... but it was done by my own students.

Mm.

The same kind of thing, it's not peer reviewed so we don't... And their excuse is, 'Oh well, the journal editors wouldn't let us reference it because it's not peer reviewed.'

Mm.

It's a very nasty period of Gaia. There was such a censorship of Gaia papers at that time, that, it was impossible to publish anything with Gaia in the title in any journal, particularly American journals, or that even talked about Gaia, or, or that had my name on it.

Mm.

And this got to the attention of Maddox, who was editor of *Nature*, and in the mid-Eighties he wrote to me and said, he thought it was disgraceful that this was going on, it was censorship of, of scientific work. And, the next Gaia paper I wrote, would I send to him, in confidence, personally, and he would see that it did not go to peer reviewers who threw it out. And I was able to meet his request, which he honoured, because the next paper was the one with Robert Charlson and Andy Endreae on the, the dimethyl sulphide as a precursor of clouds, and a way of regulating planetary climate, the CLAW paper we called it because that was the names of the authors of the paper. And that was the first Gaia paper ever to be published after the, [laughs] sort of censorship became established.

Mm.

It was a dirty business, really was.

[34:20]
Can I just ask you a quick question that I forgot to ask. Why do you think Knot... Knosser gave you... I know that you had, you had lectured for him. Why do you think he was... what about Gaia particularly interested him?

Knosser?

Yes.

Don't know him.

Oh, I'm saying the name wrong in that case. The donor for the conferences?

Oh Kloster, Knut Kloster.

Sorry. Yes.

Yes. No, why did he...? Oh, I think he was much more emotionally attracted to the idea. I don't know, I mean, he had read my first book, as Crispin Tickell had, and, liked it, and had been, how can I put it, kindlily disposed towards the idea from then on.

Mm.

And he saw, the concept of the Earth as a great system that self-regulated appealed to him philosophically.

[35:19]
I see, thank you. Now would you please describe your meeting with Margaret Thatcher, which I think happened through relations with Crispin Tickell?

That's right. Towards the end of her reign, [laughs] if you could call it that, Margaret Thatcher became interested in global climate, mainly because Crispin Tickell was an amateur climatologist, more than an amateur, I'd call him professional, and he had written a book on it. And, he was the senior position as a number one figure in the Foreign Office, in the Civil Service, a sort of, a Sir Humphrey of the, of that, for that sort of stuff, brought him in contact with Margaret Thatcher, and climate must have come up sometime and he started talking about it and found her, as a scientist, very interested and considered it an important matter. And knowing Margaret Thatcher, I can just imagine the, the thing, [laughs] 'But this is so important Crispin, we'll have to have a meeting on this, we'll have to do something about it.' And she did. I mean she was never one to stand around and do nothing. And, it led to, she first of all, she invited me to dinner at Number 10, and, I was quite pleased to go along there, you know, it was quite an excitement to go to Downing Street and have a dinner there. And, when I went in, it was a dinner in honour of the President of Bangladesh and his wife who were there at the time, and I was just one of the sort of, dinner fodder or

whatever you call it. And I thought, oh well this is very interesting, I mustn't expect too much. I was in the parade and introduced and shook hands with all of them including Margaret Thatcher. And then went round, had a few pre-dinner drinks or whatever and sat down at the long table in my position next to somebody from the Ministry of Health. And we had a long discussion about things. And, then afterwards we went to a, a kind of, separate room for coffee and, whatever, and, I thought, oh well this has been a pleasant enough evening and that's, that's that. And I was standing against the wall, or, my back to the wall, somewhere in this room, and in marches Margaret Thatcher through a door, looks around, sees me and makes a beeline straight across the room to me. And she said, 'Ah Professor Lovelock, I'm so glad you could come along tonight. There's a lot of things I want to talk to you about.' And then she'd go straight in to the whole environmental stuff, on Gaia, the climate and all the rest of it. And it goes on for about twenty or thirty minutes. And, gradually all of the rest of them around the room were looking, who on earth is this man that [laughs] has gathered so much attention so suddenly? And, I think the upshot of it was that we should have a seminar at Downing Street, and that of course was arranged some time later.

[38:23]
Are you able to remember what Margaret Thatcher said to you? I know that she had read your book. Are you able to remember any questions that she asked you, or comments?

Oh yes. She was asking how real I thought the carbon dioxide increase would be as far as climate change goes. Because that was very much on the agenda in those days. The very notion. It was before the IPCC was formed, but it was in the air, its formation, if you like to put it that way. And I was very positive then, I said, 'Well you can't go on putting CO_2 in the atmosphere indefinitely without something nasty eventually happening. Yes, it is important.' And she, she liked that, she just... She was a person who wanted straight statements. I'm afraid politicians are like that, they can't stand people who want to hedge around, hedge their bets on the way. And being independent, you can do that. I didn't have to look over my shoulder, am I going to upset my boss at such-and-such by talking to the Prime Minister about it?

Yes.

So I could be completely frank and open. And, oh she seemed quite happy about it. And I remember, I made some remark, and that was when somebody else had eventually had the courage to come in and interject who wanted to say something to her. And, she said some parting words. And somehow I said, 'Oh this whole affair, it's a bit like the Falklands, it needs a strong, [laughs] a strong leader to get us right.' And she absolutely beamed at that. [laughs] I'm not a politician but I had obviously chosen just the right thing to say at that moment.

Mm.

And, it was a, no, it, it was a pleasant experience, let's say, and so was the seminar that came afterwards.

Did she ask you any questions, any other questions in particular about your book, do you remember?

One or two, but it's so long ago now, I can't remember any details about it.

[40:11]
No. Now the seminar that followed...

That was much more significant.

Could you describe that? Because, it contains, or, members included yourself and Crispin Tickell, but there was Bob Watson and Sir John Houghton...

That's right.

...and various British and American atmospheric scientists I think.

Yes, that's right.

So, would you please be able to describe that, that meeting, who was there, what was discussed, how they were, it was discussed?

It was a typical atmospheric science meeting. I would say it was the first seminar of the IPCC, you could almost say. An informal seminar that was soon followed by the founding of the IPCC. I think, Bob Watson, who at that time was not in Britain, he was, I think Chief Scientist for NASA, was there, and so was Robert Oppenheimer, I think he was one of the prominent Green lobbies, leads one of the prominent Green lobbies in America. Both of them very left-wing. And, I sort of knew Bob Watson moderately well so I came out to him and said, 'How did you like it?' at the end. And he and this Oppenheimer, they said, 'We were astonished.' They said, 'We had never expected anything vaguely like...' He said, 'It was just like a first-class scientific meeting.' He said, 'You had never expected to see...' they'd got it wrong, head of state, because, she wasn't head of state, she was head of the government, head of government, 'who could handle a scientific meeting, if she'd been a lifelong runner of scientific meetings. She's one of the best chairmen I've ever seen at a...' And she was. She fielded all the, the questions and things in the most effective manner. And they were just astonished. And, and as I say, that, that was a real tribute, coming from two quite strongly left-wing people who would normally have been sort of, very anti-Thatcher.

Mm.

And, so I think that really sums it up.

And how did the, what arguments were presented and, what...?

Oh there, there wasn't much doubt really, there were no doubters present. It was just, what's going to happen? And there were the usual graphs and things that were around in those days that, well if CO_2 went on going in the atmosphere, it's not all that difficult to predict what it would be if all, nothing else changed. And, there were graphs of the rate of rise of things, and, the projections for the future. And then... and they didn't look good.

Mm.

Rather similar to what the IPCC produced up until this century when things began to get a bit more complicated. So, it really set the scene.
[43:06]
What was interesting at that seminar was the dinner. There was a dinner at Downing Street that we had after the thing. Lunch would be better, not dinner. And, it was in a big room in Downing Street, and there were round tables and at the head, at each table was one of the ministers of the Thatcher Government of those times, and the Prime Minister herself was at one. I was lucky enough to be at the one where she was. And, also there were Crispin Tickell, Lord Marshall, Jimmy Goldsmith, and, Lord Porter, who was then President of the Royal Society, and one or two, I think there was one other I can't remember the name of. And it was a most entertaining dinner. And she raised all sorts of subjects. And, suddenly, quite out of the blue, she said, 'Do any of you know anything about this cold fusion business?' And, I stuck my neck out and said, 'Yes Prime Minister, I think I do. I think the, Pons and Fleischmann have made quite a big mistake, and it's something that, that happens with palladium, hydrogen systems.' And, Porter immediately, 'But Lovelock, you can't say that. They, they've had peer review papers in the Royal Society, it must be all...' I said, 'No,' I said, 'I don't think it works, and I think I know what mistake they've made.' And... I didn't go into details of it because it wasn't the right place. And, at which Margaret says, 'Oh yes, well, we can forget that then, we don't have to worry about cold fusion.' [laughs]

Gosh. Nothing like direct influence that... Yes.

Well quite. But also nothing like direct answers.

Mm.

Instead of a, a lot of whiffling, 'Well it might be but on...' I knew damn well, you see I had worked for JPL on a palladium separator, which was a device that was used on the Viking spacecraft, and that's my bits of gear on Mars. What do you use in the gas chromatograph? Hydrogen as the carrier gas. And, you pass the effluent of the

column through a palladium tube, not very long, that's heated a bit, and out comes all the hydrogen, because it, it regards palladium as like blotting paper, it can't be seen, but all the other gases go through into a mass spectrometer, the sample, without destroying the mass spectrometer vacuum. There's no way they could send a mass spectrometer to Mars without expensive pumps. They would be pumps that would weigh an awful lot, and, they couldn't afford that weight on the Viking. So I invented this thing that would save JPL having to have pumps, that got rid of all the carrier gas, but still let the samples through. And that's... But, I knew when I made the thing that one of the funny things about palladium, it'll store an awful lot of hydrogen, and then quite suddenly, without any warning, at some spot on it it'll start catalytically reacting with the oxygen of the air, and all of the stored hydrogen in the bit of metal will heat up the, oxidise and heat up the metal so you get a sudden surge of heat. Which is the very thing that Pons and Fleischmann recorded and said was cold fusion in, in their thing. And I knew damn well it wasn't, it was just oxidation.

Mm.

And... They would have been dead if it had been cold fusion. You've got enough fusion going to get several watts of energy which you would need to produce perceptible heat, you would be dead from the flux of fast neutrons coming out.

Mm.

So... [laughs] So I knew I was onto a safe thing.

[46:48]
If, if you put a stop to cold fusion being taken up, did you have any sense of, what was the effect of the seminar on global warming effectively on what was going to happen next? Did you have any sense of, what your...

Yes. It was very clear that the, that Thatcher would give enormous support to the global warming thing. In fact she did so. She gave a lecture to the Royal Society on global warming, and the things, a first-rate lecture. And then, shortly afterwards she went to the UN and lectured the whole of the UN on global warming. And I think

they all thought she was mad. But part of her talk, which was quite a long one, stated, 'By the end of this century, global warming will usurp the political agenda.' Now that was as farsighted a remark, and that was made round about 1990, for any, any Prime Minister to make, and dead right.

Mm. Mm.

And, that particular speech came out of our fax machine here, two days before she gave it at New York, and she said, 'Will you please read it through carefully and see if I've made any scientific boo-boos?'

Had she?

No. Well she'd got... [laughs] I'm sure she had Crispin and several other people, she hedged her bets, and sent it down to me.

[48:13]
Now you've spoken of your impression of the Green movement at the time of the CFCs. What was your, what was your impression as you were getting sort of nearer to the, the Nineties of the Green movement, over for example, climate change? Was there a change in the British Green movement in its response to things, its reaction to things?

Not really. I was very favourably inclined towards them. And, in the early Nineties, the Friends of the Earth invited me to give their Purdy Lecture, which is their sort of special lecture they have in honour of a founder member who died, in Cardiff, on it. And I warned them beforehand, I said, 'You won't like my speech, because it's going to support nuclear energy.' And they said, 'Never mind, we want you to come along anyway because of Gaia.' So I gave them a speech, which, I tried not to be too contentious and all the rest of it. I didn't mince my words and I said, 'If you really want to have energy for Britain and not produce CO2, that's the way to go.'

Does this represent a change then? Because you were worried when you first found CFCs and you, you made the comment about, the, the fact they weren't toxic, because you felt the Green movement would leap on it and, and be hysterical about it. What...

[49:34]
I was thinking not so much the Green movement in Britain; I was thinking of the fanatical American Greens, like Barry Commoner, and several others like him, who, were in a different class. We don't have that sort of person here.

[49:50]
Mm. Thank you. Could you in a general way comment on the effect on Gaia in either promoting it or hampering it, of this increase in interest in global warming? What has been the effect on the promotion of Gaia as a theory, of its interaction with popular and political interest in global warming?

That's a very interesting question. The impression I have strongly, and one that kind of kept moving me to write the last two books I've written, was that here was an opportunity to bring Gaia before the public in an important practical context. And I think that succeeded, from all of the responses I've had, at lectures, at public meetings of various kinds that I've entered. People are much more aware of, interesting and accepting of Gaia, than they were beforehand. It's come from, you know, the, [laughs] the backstage to somewhere centre stage, not, not in the front yet, but, it's moved up quite a bit. It's had zero effect in America.

Mm.

Because they're still deep in this, almost Stone Age view of the Earth, that the Earth is... All of the, the atmosphere, the climate and everything, controlled purely by geophysics and geochemistry, it's a matter of geology, it's got nothing to do with life on the planet. And, that... And the biologists say, 'Yes, yes, it's nothing to do with life, you don't need...' It's, it's a different world scientifically.

[51:30]

And, is there a connection now between, or what is the extent of the connection now, between Gaia theory and the modelling of climate change by groups, like the Hadley Centre and the IPCC and...?

At the Hadley Centre, I think, I, I may be wrong about this, because I don't know enough about the GISS models that James Hansen and his crew are doing, although I do know one person who's been closely associated with it, that's Ann Henderson-Sellers. I don't know a lot about them. I don't know a lot about the Stanford models and so on and so forth that Steve Schneider will have been involved with. Nor the NCAR models come to that, although I've had contacts there, in America. But, I, I think, I'm pretty, in fact I'm pretty sure that the Hadley is most advanced of all the climate centres in the world, and I was there only two weeks ago, spent a whole day at the centre, and, they were telling me that, in three years they hoped to have a super, super computer at Hadley, and it would be modelled to include Gaia as much as possible in, in the whole of the, of the thing. And that's about as strong as you can get really. And I can well understand what the geophysicists have said to me beforehand at the Hadley, because, they're very friendly, I have no problems going there and talking openly to any of their... They've said, 'We'd love to include Gaia and things like that, but we haven't got the geophysics right yet. We can't put a complicated thing like that in until we've got the geophysics part of the model. The models are very incomplete still.' And that, that's from the horse's mouth at the Hadley Centre, they're admitting it, that they're, they're mainly... The way to look at it crudely is to say, so far they are not much more than souped-up weather forecast modes, looking further ahead. Which makes, this is why I get so indignant, and say, idiot politicians and people like Lord Stern, who want to introduce legislation, affect... for, for procedures concerned with the climate fifty years ahead, are mad. We have not the slightest idea what the climate will be fifty years from now.

[53:54]
And you mentioned that John Houghton was at that climate change meeting at Downing Street. Is there any link between Gaia and the IPCC in any...?

Oh, people like John Houghton have always been friendly, and, I have the greatest respect for him, I think he's a very great man as well as a good climatologist. And, I

don't know what he thinks personally about Gaia. He's quite religious, he's sort of, classic, Church of England religious, and, you know, a very honourable man. So, all I know is, friendly and supportive.

[54:31]
Thank you. There's one thing I've noticed on my pad that I meant to ask right at the beginning of the Gaia thing, and that is the role of your first wife in developing Gaia as a theory or, supporting you in its development.

Oh well, Helen was always supportive in... I mean, she went along very much with the independent life we led. I mean she wasn't ever difficult. Because, it must have been quite an awful effect on her when I decided at age forty that I was going to give up a secure pensionable occupation in a safe government department doing just the kind of work that I liked. I must be totally mad, most people would have said. My mother practically had hysterics about it. 'How can you Jim, how can you?' [laughs] 'The best thing you could... you've achieved everything that you should have wanted, and now you're giving it all up.' And, it must have seemed mad, but she was fully supportive. She didn't like much the idea of going to America, she was never very happy there, at all, and, or, and didn't like Americans very much, I think, or the culture she didn't like, put it like that. Yes.

[55:51]
To what extent was she a enthusiast for Gaia as a hypothesis and then a theory?

I don't think that, that would be quite the word. She thought that, she was very acceptive, that it was part of our kind of relationship. I accepted her views on things and she accepted mine, and it was part of my view of the world, was Gaia, and she was quite... It didn't conflict in any way with her kind of, interests in life, and, therefore, OK, I mean... And, if that's what Jim wants, and that's what he's going to be doing, I'll support it, but...

Through discussions with her, was it, was it developed through discussions with her?

No. No.

[56:35]

Thank you. And, if I ask a final question, then I would like to leave it up to you to talk about things post-autobiography that you feel ought to be included, but, my final question would be to ask you to comment on the importance of the place we're at now, Coombe Mill, in the promotion and development of Gaia, in particular the land and the way the land has been used and managed. And also your sort of, interaction with it and, I've experienced your interaction with it because we went for a walk through it yesterday.

Yes.

So, if I could ask you just to comment on the role of the place of Coombe Mill with its land on Gaia, and then invite you to talk about anything post-autobiography that you would like to be on the recording.

The problem with Gaia is, it's a bit amorphous. You can talk about it as anything from semi-religion, and there are certainly people who take it that way, right the way down to hard science. And everything in between. It, it's not... I mean it's relevant to all of the disciplines of science, including geography. And, it, so it's not so easy to talk about in, in that sort of, wide context. Coombe Mill must, must play a part in my thinking, because I chose to come here, and it's certainly a place you can work independently. Its main drawback is difficulty of getting anywhere else, but that may be a good thing, [laughs] because it stops me spending too much time going to London to meetings and things like that. I can spend all my time doing that sort of thing if I accepted all the invitations. So, it, it's a kind of benign prison in a sense. [laughs] The snug jug as they refer to it.

[58:39]

I don't think it's played a big part in the development of ideas. Because what I've done here has been largely mistakes, like the planting of the 20,000 trees. I should have left it along and let the land plant its own, have more faith in Gaia in other words. But, you learn from your mistakes, so, I guess that's part of it.

[59:01]

Does Adrigole have a more important place then, being the place where you sat and looked across and wrote the first book?

I think you're right there. That was a very prescient remark. I, I feel Adrigole is more associated with Gaia than almost any other place. And it was a heavenly place in many respects. There was the, the sea and the lighthouse out in front, and the gorgeous mountains going in all directions, and Hungry Hill just at the, grew straight out of the garden at the back, you could climb to the top of it and see for miles and miles. No, it was a, a very special, splendid place, was Adrigole.

And I'm right in saying that you sat on, there's particular slabs on the hill?

That's right, yes. It was a mass of sandstone slabs, and when it was a sunny day and the sun was warm, they were gorgeous to sit on you know. Their angle's about forty-five degrees. They were just steep enough... Sorry. It was not so steep that you couldn't climb up it, you know, just walking with rubber-soled shoes on a dry day. It was hard work but you could get up it. I could even, when I was younger, run down it.

[01:00:19]
Mm. And would you be able, do you think that there are, the particular way in which you wrote that first book, the particular way in which you formulated it in words, does that have any direct link with the view, the view from Adrigole, the view from the hill?

Probably. Probably, yes. Because it puts you in the right frame of mind for, feel a part of the world. Also, it was a part of the world where there was minimal human intrusion, just the subsistence farmers with their small cottages nearby, but, hardly anything anywhere at all.

[01:00:55]
Mm. You mentioned that your neighbours around Coombe Mill now often stop you and speak to you.

Yes.

And, when they talk about the weather for example they are often asking you to, to predict. I wonder whether you could say a little bit about your neighbours here now.

Oh the, the neighbours around Coombe... It's a strange area of west Devon, this. It's called by Defra the, or whatever Defra is called nowadays, they keep changing their name, the Wild West, because they're the least law-abiding group of farmers I think in the country. And, they are simple peasant farmers doing what I call almost a lazy form of farming. It's buying in cattle from outside, when they're young calves, and then rearing them and selling them at the end of the summer, just feed, letting them feed on the grass that's part of the, thing. Not too many of them, carry them through the year, and still fewer do milk production. But that may not be their fault. The, the milk quotas and things make it quite, quite tricky to become a milk farmer. Anyway, they lead relatively benign, comfortable lives, doing, looking after their cattle or sheep, and, they don't intrude in the countryside. It's more old-fashioned farming, it's not like the grain farming of East Anglia where everything is ripped out and just one gigantic field that you pound with tractors and pour on pesticide and fertiliser and, get every, every ounce of anything out of the soil. Much more gentle farming here, and, it's more like the old-fashioned farming that, that I grew up with. As you can see in the little roads around here, it's muddy and messy, but, that's acceptable. They all have their battles and they're up against it. They had plenty of trouble when the foot and mouth came around. This area just escaped it, and, which was lucky for them, but I'm sure they had a great deal of anxiety about that.
[01:03:14]
And, recently food prices have begun rising and the need for farming has increased, so their future looks fairly good. They're much more cheerful than they were a few years ago when things looked quite bad.

[01:03:28]
And what's your impression of how they see you and how they understand what, what you are as a scientist?

Well, it took a little while to accept me. I mean they didn't know what, what I was, or whether I was going to be a nuisance to them around, or whether I was going to be an

asset. And they don't like making up their mind about anything. They've learnt that way as farmers, you, you take things as they come and then slowly form an opinion. But we seem to have met their criteria and, as we go around we spend quite a long time stopping and chatting with them about something or other. And they all know, all of the farmers know me by name. But, [laughs] I tend to forget sometimes who I'm talking to. I'm not just talking around here, but I'm talking about even, you know, two or three miles away, you know.

And what's the effect on their knowledge of what you do on the sorts of things they say to you?

Oh a lot. I mean they want to know, they want to know... They're quite... Farmers have got a much greater vested interest in the Earth and what it's doing than the average townie has, obviously. So they're much more int... their questions about Gaia and whatnot are much more intelligent than most, regardless. Because it's real to them. Whereas to a town-dweller, apart from Green nonsense, they don't really know much about it at all.

And what are they, what are they wanting to know from you?

Mainly what's, what's it going to be like this summer? And, I, I refuse to be drawn on those sorts of questions. Occasionally I'll drop hints, if I feel fairly sure.

[End of Track 13]

[End of Interview]

