G. A. H. ELTON - LIFE STORY

(Note: this is about my scientific life - the family is another story!)

Early years

I was born in Wimbledon on 27th February 1925. My father Horace William Elton (born 4th August 1895) had met my mother Violet Evelyn (Clowes before she married; born 27th July 1900) when he was serving in the Machine Gun Corps during the First World War - and she was working in a baker's shop in Chesham. They married in 1922 and were living in Wimbledon where my father was working for the coal merchant Hoare Gothard & Bond (taken over by Eastwoods after the Second World War). They were living in digs - one-room furnished accommodation at 49 Evelyn Road, Wimbledon, SW19. The landlady was Mrs. Hobson with whom they kept in touch. I was actually born at the Nelson Hospital in Wimbledon.

When I was about a year old, we moved to Camden Town because Dad had been transferred to the Hoare Gothard & Bond branch at St. Pancras. He came originally from Camden Town, and had worked at the St. Pancras branch before the War. Dad's mother still lived there - at 17 Elm Road, and we moved into No. 19. Grandma's maiden name was Edith Clara Church (born 1861), and she had married William George Elton, a carpenter. They had two sons, but one of them, David, died young. Nos. 17 and 19 were old but respectable 3-story terraced houses, with a different family living on each floor, sharing a bathroom/lavatory between all of us. The lady upstairs was called Mrs. Billingsley.

My earliest memories are of when I was about 3: (a) being bitten by a dog; (b) being frightened by a mechanical Felix the Cat at a big shop (Selfridges?); and (c) listening to the wireless on headphones and a crystal set. As I remember it we had one living room/kitchen and one bedroom which I shared with my parents. My favourite toy was a soft grey and white rabbit called Poggy. My mother used to take me in my pram and later walking to Parliament Hill Fields, and along the towpath of the Regent Canal where there were frequent barges going by, all towed by horses walking along the towpath. I remember when I was about 4 or 5 being taken to a fair on Hampstead Heath with steam-driven roundabouts and boat-swings and coconut shies. I used to watch the trains in the St. Pancras shunting yards out of our window, and look for the occasional truck labelled GE - from the Great Eastern Railway.

At the age of five I started school at Brecknock School - my teacher was Miss Amphlett. We wrote on slates with slate pencils and did drawings and sums with white and coloured chalk on brown paper. There were a few toys locked away in a toy cupboard and brought out on special occasions such as the last day of term. On Saturdays my mother sometimes took me shopping in Kentish Town - and I was usually feeling sick by the time we got off the tram.

In 1931, when I was 6 we moved to Morden where a new council estate was being built to house people coming from the slums of London, plus people like us coming from places which were not slums but were old-fashioned and cramped with few amenities. I remember being told with great ceremony that I would have a room of my own - and so I did. The council houses were brand new - two bedrooms each,

terraced and we were in an end terrace (140 Lilleshall Road), so we had a side gate to the envy of some others. We also had a proper bathroom. Whereas at Elm Road it was necessary to boil kettles and pans of water and carry them upstairs, at Morden there was a coal-heated copper in the scullery and when the water was hot enough you pumped it up into the bath above with a hand-pump (a job I often had to do when I was older - it took ages and made your arm ache.) After a while I was given a black and white dog called Scamp of which I was very fond, but he died after a year or so. He was replaced by a smooth-haired black and white cat called Tommy who lived to a great age.

I started school at No. 1 School in Middleton Road, about a mile away because No. 3 school 200 yards away was not yet finished, but transferred there as soon as it was. My schoolteacher was Mr. Cuthbertson, and you moved up through the school year by year with the same teacher. When I was 8 I joined the Wolf Cubs and also began to play cricket and football in various school teams. School equipment was very limited by today's standards, and books were passed on from year to year, but we got a very sound grounding in arithmetic, handwriting (copying figures and letters out of copperplate books), English, history and geography. We learned our multiplication tables by heart, starting from 2x and working up to 12x, so even today if someone says eleven elevens? I automatically answer 121.

When I was about 7 my sister Mary was born (on 27th June 1932). I went to school one morning and when I came back I was told ''d got a new sister. She shared my parent's room, and continued to do so (with a curtain divider) until she was about 15, when we moved to a 3-bedroomed semi-detached council house at 39 Seddon Road.

Dad was still working at St. Pancras in the 1930s, and used to catch the workmen's train (before 7.30am) every day because it was cheaper (half price). Like most people he also worked on Saturday mornings, and once or twice I went up with him, and was usually nearly but not quite sick on the train each way. The Northern Line Tube had been extended to Morden in about 1930, making the Morden to Edgeware tunnel the longest in the world at that time; the journey from Morden to Camden Town took about 35 minutes.

When I was just 10 (February 1935) I sat for what was called in those days the Scholarship Exam (later followed I suppose by the eleven plus, but not quite the same). This involved quite a long exam, and an interview on a separate day for which I was turned out in my Sunday best, hair combed and enjoined to salute the examiner smartly when I went into the room, which I duly did. There were a lot of verbal questions, one at least of which I later realised I had got wrong – "If you saw a man standing at the corner of the street wearing blue, would he be a policeman?", and having been used to answering questions yes or no, after some thought I said yes - while the answer should have been possibly yes, possibly no. Still, I passed the exam which meant that in September I should go to Sutton County School (a grammar school) with all my fees paid (most of the boys' parents paid fees), and with free school dinners provided.

My parents were not very well off and had a hard time providing the school uniform from the list sent to them - red school blazer with an owl on the pocket, red and black cap with a metal owl badge, red and black socks, gym shoes, satchel, etc. They also had an interview with the headmaster who said that like all the scholarship boys I would go straight into the Second Form in September, although I would be only 10 & a half, and the average age was nearly 12. Did they want me to go into Science II, Classical II or Modern II? After some thought they said Science II and the die was cast. The different second forms (about 30 in each) did lots of things in common, including PT, games, scripture, English, geography, but Science II did chemistry and physics, Classical II did Latin and Modern II did German (we all did French).

I duly started in September 1935 and worked my way slowly up the school, nearly always finishing in about the middle for Form Marks in the class of 30, and always being about 18 months below the average age. This was probably good for me because it set a high standard, not only for school work but also for games where I was always competing at boxing, cricket and football with boys who were bigger than me. I used to enjoy most lessons, with maths, chemistry and physics my favourites, English, French, history and geography in the middle and art worst of all. I sang in the school choir, our big moment being on speech days when we sang the school song *Floreat Suttona* - we also went in for various choir competitions with the usual repertoire - *Nymphs and Shepherds*, *Jerusalem*, *Marching through Georgia,* etc. Our big set piece was *The Pied Piper of Hamlyn*, which was long and performed only on special occasions.

When I was about 11, I joined the Boy Scouts, having been a Wolf Cub for 3 years. This involved one evening a week of teaching (knots, first aid, etc.) and games, plus church parade on Sunday, where I occasionally carried the flag with pride as we marched to church with the drum and bugle band. There were also occasional camping weekends under canvas.

I played cricket and football as much as I could in form teams, house teams, scout teams, etc., and boxed and took part in school sports days. The school was organised into four Houses, and everyone did their best on these occasions to win points for their House to decide which was the top House for the year. I was in Red House and had a red V under the owl on my cap. By the time I got to the Fifth Form (1938-9) I was appearing occasionally in the School First team at cricket, where I opened the batting with Dave Fletcher (D.G.W. Fletcher, later the Surrey opening batsman for many years).

In June 1939 we took our General Schools Certificate examinations (roughly equivalent to today's O-levels). If you got 5 Credits you also got the Matriculation Certificate which was the first stage of qualifying to enter a University (if you could afford it!). I was only 14, but I managed to do well with Credits or better in English Grammar, English Literature, French, Mathematics, Chemistry, Physics and Geography, and a weak pass in Art (much to everybody's surprise as there was strong betting that I would fail in Art - few were more surprised than me).

The war years

When the war broke out that summer (3rd September 1939), I was on holiday in Ampthill in Bedfordshire. Going back a bit, we were never well off; my parents rarely if ever had holidays, but I was lucky and was sent off to one of my mother's sisters, either to Auntie Barbara in Churchover or to Auntie Lil at Greatstone (she plus Uncle Trew (Pledger) and cousins Val and Dick lived in Tooting, a highly respectable area then (he was manager of a local milk-bottling plant), and they went on holiday to Greatstone every year). Twice I went on free holidays provided by the local Rotarians - one to Milford and one to Weston-Super-Mare, both at Rotary children's homes. Once or twice (when money was easier I suppose) we went off to Fawley in the New Forest (now the site of an enormous oil refinery, but then a small village deep in the country - near to Calshott on Southampton water, where the Schneider Trophy Seaplanes came from). At Fawley we stayed in a cottage with Mrs. Nason and her son Rodney; no mains water or sanitation, but a beautiful spot. Dad had been there on holidays before 1914. There are still some old photographs about of Rodney and me with shrimping nets.

Back to 1939 - I was at Ampthill because the people who used to live next door to us (at 138 Lilleshall Road) had fallen on hard times and had moved up there so that Mr. Smith (Spider to his friends) could

get a job driving for the local brickworks (Marston Bespress, big orange lorries), near Bedford. They lived in a cottage just outside Ampthill in what was then deep country, so I was sent up there for a holiday in late August 1939. I spent happy days with their twin sons, Wally and Harvey Smith, playing in the woods and fishing with bent pins in the local stream.

When war was declared, a telegram came saying that a driver that Mum and Dad knew was going to be up at Bedford that evening, and would pick me up and bring me home. So he did, and that was the longest car journey I had ever made (probably about 60 miles). I got home to find all the windows covered in sticky-paper crosses to prevent splintering in case of a bomb nearby, and everything blacked out - no streetlights, and no lights to be shown from houses, i.e the black-out had started and would go on for 6 years. Dad was an Air-Raid Warden, and I had joined the ARP (Air Raid Precautions scheme) as soon as I was 14. Everybody was issued with gas masks and had to report to the local school (a) to be checked that they knew how to put them on properly, and (b) to have an extra filter taped on to the front to cope with arsenical smokes which had just been thought of. As an ARP assistant, I helped with this, needless to say in a minor capacity.

Looking back on it, it was obvious that the war had been coming inevitably for a long time, but everyone had been hoping against hope that it would be averted, especially those with memories of the Great War which had ended only 21 years before, and in which millions had been killed. So everyone was expecting immediate air raids with bombs and gas, and nothing happened for several months. The British Army went over to France, and young men started being called up, but from September 1939 till May 1940 we had the period of the 'Phoney War' when opposing armies faced one another and exchanged a few shells, but very little real fighting took place. In reality, of course, Hitler was building up his forces and getting ready for a massive attack, which happened in May 1940.

The Germans swept into Belgium and Holland (neutral until then) and outflanked the Maginot Line (a fortification in depth on which the French were relying for protection). The British Army was exposed on the flank when the Belgians collapsed, and fought a rearguard action back to the coast. In June 1940, hundreds of thousands of British Army men (including several of my friends) were rescued from the beach at Dunkirk by a strange mixture of pleasure steamers, fishing boats, private yachts, motor boats and every conceivable kind of craft under constant air attack. They got back to England, but mostly without weapons - and of course with no tanks or heavy transport. And many (also including some of my friends) stayed behind on the other side of the channel, either dead or as prisoners of war

Everybody got ready for the expected invasion of England - beaches were mined and covered with barbed wire; concrete pillboxes were built at road junctions, and obstructions set up on all big fields to prevent landings by aircraft or gliders. The German Luftwaffe started bombing our airfields; I was uncomfortably close to one of these raids. My cousin Dick and I were out on our bikes and decided to visit Croydon to look at the aeroplanes as we often did - RAF Hurricanes were based there. When we were about a mile away, without warning there were explosions and a roaring of zooming and diving planes as German bombers attacked the airfield - plus scattered antiaircraft fire in return. After a few minutes it was all over, and, soon after, they had gone the air raid warning sounded (a bit late!). Many people were killed that day, not only at the airfield but also in surrounding factories and houses.

Meantime I was still at school, hoping to go on to do Higher Schools Certificate (now A-levels), and in June 1940 took successfully some extra O-levels - Applied Mathematics and Mathematics More Advanced. Unfortunately what with pressures on the family finances plus war difficulties I was unable to stay on at school and left at the end of 1940.

Before that, however, in the summer holidays of 1940 I worked on a farm in Avebury, Wiltshire, helping to get the harvest in - particularly important in those days of course, when it was very difficult to import food because of U-boat attacks on shipping. I worked (along with everyone else on the farm) a 12-hour day, six or sometimes seven days a week. I got what I then thought was very good pay - sixpence an hour (equivalent to two and a half new pence per hour in today's money), less deductions for food and accommodation (straw palliasse in a barn). Nearly all of the power on the farm was supplied by horses; there were virtually no tractors, and I was engaged with others in 'stooking' wheat, barley and oats, lifting sheaves in the fields with pitchforks on to high-stacked wagons, transferring sheaves from wagons to barns, and feeding the threshing machines which were run by a steam-engine. Very tiring work.

When the harvest was in I cycled back from Avebury to home in Morden, about 80 miles. That was September 7th 1940, and I remember the date very well as it was the day when the Germans gave up concentrating their bombing on airfields and other mainly military targets, and mounted the first massed raids on London. There were air battles going on overhead as I raced the last few miles home, and into the air-raid shelter with my parents and sister. At this stage there was a large communal shelter (basically a covered-over trench) at the end of Muchelney Road, about a couple of hundred yards away, but soon we got our own Anderson shelter in the back garden; I helped dig the deep hole and set up the curved corrugated-iron strips, then cover it all with 2 feet of earth. Shelters like these provided good protection from blast, splinters, etc., though not of course from a direct hit. People made them quite cosy inside, and many used to sleep in them all the time when the bombing got heavier.

When I left school at the end of 1940, I went to work in a chemical factory - British Hydrological Products Ltd. at Merton. They made all kinds of chemical cleaners for industrial and domestic use - mostly based on concentrated caustic soda! In those days there was not much choice of jobs; I was a mixer's assistant, and also did some work in the control laboratory (because of my O-level in chemistry). The mixer's assistant job was rather heavy work, with a fair amount of carrying of sacks of sodium hydroxide, sodium carbonate, etc. I stayed there for a few months before moving on to the coal merchants Hoare Gothard & Bond. Dad had been transferred back to Wimbledon again to manage the local office, and I worked at Wimbledon and also at New Malden, wherever I was needed. Staff was so short that I occasionally used to be in charge at the New Malden office. I helped with the paperwork, and also on the wharf, and kept the tally of how much coal and coke came in and went out. One day a 500-pound bomb dropped at New Malden no more than 20 yards from where I worked and killed several people, but luckily for me I was at Wimbledon that day. It was at the Wimbledon office that I first met Ron Chamuffin, who was the office boy, and our friendship has lasted until this day (see more of this as we go along).

In September 1941 I started week-end classes at Kingston Technical College (a nine-mile bike ride from home), hoping to get my Intermediate B.Sc. (now roughly equivalent to A-levels) and qualify for a job that was permanently indoors! All evening classes had been cancelled because of the bombing and the blackout, so instead of doing the usual five nights a week of evenings we had to do 12 hours at the weekends - 4 hours on Saturday afternoons (everybody worked at their normal jobs on Saturday mornings of course), and 8 hours on Sunday. This was quite good fun but meant that in term time you worked 7 days a week for 13 weeks on the trot before the luxury of holiday time when you worked only five and a half days a week. Needless to say, there was not much time for social activities, even if we could have afforded them.

With regard to pay, I should have mentioned that when I started at British Hydrological Products I got 18

shillings per week (i.e. 90p per week new money) for a 44-hour week. Stoppages like tax and National Insurance came to 2/= and I gave my mother 11/= but that left me the luxury of 5/= a week for myself. You could go to the pictures for 9d. (equivalent to three and three-quarters new pence). Sweets were very hard to come by (they were rationed later) and so were clothes (also rationed later). Later on, my friends and I at Kingston Tech used to put sixpence (2 1/2p) per week into a kitty to fund an evening's merrymaking at the end of each term (sausages and mash plus a couple of pints of beer). I reduced expenditure with regret when my old favourite 2d. weekly paper the *Magnet* stopped publishing at the end of 1940 (Dad had read the *Magnet* as a boy), and its tales of Greyfriars School, Billy Bunter and the Famous Five were sadly missed. When I moved to Hoare Gothard & Bond, a big lure was that I was paid £1 per week, i.e.2/= more than at BHP.

I enjoyed my first term at Kingston, and, in January 1942 something happened that started me off in my career in science. A vacancy occurred for a laboratory assistant in the Biology Laboratory, and although I was not doing Biology (I was doing Chemistry, Physics, Pure Maths and Applied Maths for Inter B.Sc.), I was offered the job. I jumped at it because (a) it paid 22/6d per week (£1.12p new money); (b) it was indoors all the time; (c) I got one afternoon a week allowed to attend classes in the day-time. This enabled me to learn a lot quicker, and I had ambitions to do my Inter B.Sc. exam in November 1942 (because of the war exams were held twice a year, in June and November - June would be much too soon but I might make it by November) - and, as you may have guessed, laboratory assistants with Inter B.Sc. got paid more than those without it. In those days you had to take four subjects for 'Inter', and what's more you had to pass them all at the same time. People sometimes passed 3 subjects and failed one, and had to take all four again. The only relaxation was that if you passed 3 and only narrowly failed the 4th you might be 'referred' - i.e. allowed to take just that one again. However in due course November came round, I took the exam and managed to get 4 Bs (the levels were; A - distinction; B - good; C - pass; D - fail, but might be referred if you passed the other 3; E - fail).

So I got my extra 5/= per week; I also supplemented this by doing firewatching, for which 4/= per night was paid. This involved four of us spending the night in camp-beds at the College, and taking it in turns to spend 2 hours on the roof watching for incendiary bombs, etc. The seven-day weeks continued, which made it difficult for my cricket and football, so I was confined to playing at the weekends out of term, and to evenings for cricket in the summer.

Also in November 1942, I reached the age of 17 years 9 months, which meant that I had to register for National Service - the idea was that you registered, had your medical, and then got called up when you were 18. I went along to the local Labour Exchange to register on the appointed day with my friend Dinky Simmonds, who was exactly the same age, and we applied for selection as RAF Aircrew. We both passed the ordinary National Service medical A1, then went for the much more searching air crew medical. Dinky was accepted for training as an Air Gunner because he did not have the necessary maths qualifications for pilot training. I did have the necessary maths, but was told I'd be put on deferred service for a year to eighteen months, which meant that I wouldn't be called up until required. But air gunners were needed right away; Dinky went off and got through his course. Unfortunately his Lancaster was shot down over the Ruhr in 1944 and he was killed.

Still that was all in the future, and of course I did not know that that was going to happen. I calculated that in 12-18 months of deferred service I might have a chance at getting a B.Sc. degree. This normally took 3 years, but because of the war they were cramming people through in 2 years (they still had to cover the same syllabus, just had to work longer hours). To do it in 18 months at the weekends seemed a bit unlikely, especially as there was no degree course at Kingston! Still, the chemistry lecturer Mr.

Parke wrote me down a list of subjects to read up, and so did the physics lecturer - maths I had to do entirely by myself, but I'd got the syllabus; so I had a go at doing a London University External B.Sc General and sat for it in June 1944.

This was just at the time of the Allied invasion of Europe (D-Day), and also the first flying bombs (V1) were coming over. I took my exams with many others at the old Imperial Institute in South Kensington, and the big examination hall had a glass roof. In the middle of one of the chemistry papers the air-raid sirens went, and the anti-aircraft guns started banging away at the doodlebugs as the V1s were known. We were all marched down into the cellars leaving our papers behind and allowed to go back and finish the time when the all-clear went. Somehow I managed to pass and there I was - B.Sc.! Only 19 and done by private study - if I'd known then what I know now I'd probably never have tried it.

I devoted all my spare time for the rest of the summer to playing cricket! Except that from time to time I played the drums in the college band which performed at dances at the Tech and elsewhere in Kingston. Traditional jazz was our main aim, but we also had to do a lot of quicksteps, waltzes, foxtrots, tangos, rumbas, etc. - piano, clarinet, trumpet, banjo plus occasional odds and ends from other people.

In August 1944 I was told that now that I had a degree I could not be considered for air crew service as they were very short of scientists for defence work. So I was called up instead into the Department of Scientific & Industrial Research (DSIR), and posted to the Smithfield Laboratory which was then occupied by the Printing & Allied Trades Research Association (PATRA), most of whose staff (about 30 graduates) were on war work.

My main work was to be as a small part of the Tube Alloy Project (TAP) of which of course I had never heard. For the next year or so I worked under the supervision of Dr. W. H. Banks; TAP was closely linked to a project in the USA - the Manhattan Project - in fact this was the work on the first atomic bomb, my tiny bit being related to gaseous diffusion of uranium isotopes, for which "Dr. W.H. Banks and his team" received official recognition in the report on the British contribution to the atomic bomb. I also worked under the supervision of Dr. G. Macdougall on a variety of odds and ends of scientific work that happened to be given to me.

Battersea Polytechnic

Both Dr. Banks and Dr. Macdougall were nice chaps, and both had got their Ph.Ds in the early/mid-1930s as day-students at the famous Battersea Polytechnic, as indeed had the Director of Research, Dr.G.L. Riddell. I started work at the Smithfield Laboratory on 1st September 1944, and by 8th September they had me along at Battersea Polytechnic registering for a Ph.D. evening course! The Head of the Chemistry Department, Dr. Joseph Kenyon, FRS, was not keen on taking me on as I had not got an Honours degree in Chemistry, only a Pass (General) Degree in Chemistry, Physics and Mathematics. However, because of the recommendations from Drs. Banks, Macdougall and Riddell, he did let me in - on condition that in one year I passed the Associateship examination of the Institute of Chemistry (now the Royal Society of Chemistry).

This was (and still is) an exam of Honours degree standard with a particularly tough 4-day practical examination. Needless to say, I agreed to do this, and arranged to put in 5 nights a week at Battersea with the aim of getting my Ph.D. in the minimum time (for evenings) of 4 years - Battersea being an Internal College of the University of London. At the same time I arranged to spend Saturdays at Kingston Tech feverishly covering all the practical work for the Associateship - and Sundays studying up the

theory for the AIC exam, which I had to take in September 1945. To cut a long story short, I did pass the AIC, and was duly admitted as an Associate when I reached my 21st birthday in February 1946. I later became a Fellow of the Institute in 1951.

My supervisor for my Ph.D at Battersea was Dr. J.W. Smith, Head of Physical Chemistry, who later became Reader in Chemistry at Bedford College. I worked on colloid chemistry, with particular reference to the electroviscous properties of thin films of electrolyte solutions (which, believe it or not, came in very useful in two of my subsequent jobs). Every night after work, I walked along from Smithfield to Blackfriars Bridge, caught a tram to Westminster, then another tram (No. 31) to Battersea. At the end of the evening's work (9pm), it was a bus to Clapham Common, a tube to Morden, then a bus home, getting back about 10.30pm - then up at 6.30am next morning to go to work. Funnily enough, I enjoyed it.

In the meantime I had also become a Gas Identification Officer (GIO) in the ARP (by then known as the Civil Defence), which meant that I was one of four people who would be responsible within Merton & Morden for detecting poison gas in the event of an attack; identifying what gas it was (we carried a complicated chemical testing kit); and taking the necessary measures to counter it. In the event of course, gas was never used. However V1 strikes continued, and the V2 appeared, a rocket which travelled at above the speed of sound, and arrived with no warning. In about November 1944, I was one of the many people involved in the clearing up and rescue after a V2 rocket hit the Smithfield poultry and fish market, 300 yards from the Smithfield Laboratory. 20 people were killed and a lot injured. (Talking of the Civil Defence work reminds me that I have forgotten to mention that I was in the Home Guard from 1941-42.)

After the end of the war, time went by very quickly. 1947 was notable for two things (a) I met Mum, and (b) I changed my job. Mum, then Theodora Kingham, was a Domestic Science student at Battersea, and we met at a Polytechnic dance in June 1947. We got engaged a few weeks later, and that led of course to the start of a whole new story, and eventually to several new lives! We were engaged for three and a half years before we were married. This was fairly normal in those days, as it was necessary to save up the necessary cash, and clothes and furniture were still rationed. More of that later!

On the job front an Assistant Lectureship in Chemistry became vacant at Battersea, and I was asked if I would like to do it. I naturally jumped at the chance - it would be an interesting job in itself, and it meant that I'd be spending all my time at the Polytechnic, which should help with the Ph.D. So I started work there in September 1947 after a happy and interesting 3 years with DSIR (my National Service obligations had been fulfilled by the war work). When I started lecturing the usual thing was to have a work load of 24 hours lecturing and practicals per week, the remainder of the time being available for preparing lectures and doing any research you could fit in. Nowadays the average university lecturer may do 50 or 60 lectures a year. Still, I enjoyed it and there were always the evenings for research. I lectured on physical chemistry at Inter B.Sc. and 1st year B.Sc. levels, plus some 2nd year B.Sc. In 1947, many of the students had just come out of the forces - one had been a lieutenant-colonel, another a squadron-leader and so on - a lot of them were older than me. Still I did a lot of reading in order to make sure that I stayed at least one bound ahead of the class.

I had by then acquired a motor-bike. I bought my first one (a 1933 Triumph 500cc Competition Single) from Ron Chamuffin in May 1945 - petrol was still rationed then. Ron and I also owned jointly a 1930 Austin Seven car which we bought for £5 - it went, just about, although it often had no floorboards due to operations going on underneath. Others of my friends in the motor-bike coterie were Ernie Gates (ex

Kingston Tech and PATRA), Stan McEwen (ex Kingston Tech) and Christy McGrane (also ex Kingston Tech). Ernie Gates had an ancient 1928 250cc BSA, Stan had various bikes, but mostly a 1933 Francis - Barnett, while Christy had a dreadful 1924 Douglas. All of these bikes cost about £10 - 20 or so, which was thought to be a lot of money. I later went on to a Government-surplus 1938 Royal Enfield 350 before eventually giving up motor-bikes some time before I acquired a proper car.

Back to work. I had started publishing my first scientific papers in 1946 - my first was a short one on some of my Ph.D. work in the Journal of Chemical Physics, then I had four papers published in the Proceedings of the Royal Society in 1948/9 (and eventually finished up with over 140 papers). I got my Ph.D. in September 1948 (examiner Professor N.K. Adam of the University of Southampton - I still remember some of the questions he asked me in the viva exam!). Soon afterwards I was promoted to Senior Assistant Lecturer, which was a step-up in pay and seniority, and early in 1950 I was appointed an Assistant Examiner in Chemistry for the London University Intermediate B.Sc. examination (less than eight years after taking it myself, although I kept quiet about that!). This involved marking literally hundreds of exam papers, not only from all over England, but also from abroad - people sat for the London Inter in India, Kenya, Egypt, etc. I got paid 1/6d (7.5p) per script marked. I also had to be one of the supervisors of the practical exams at the Imperial Institute.

On 22nd March 1951, Mum and I got married at the Woolwich Registry Office. Before that she lived with her Mum and Dad at 11 Vincent Road, close to Woolwich Arsenal Station. Our first home was 54 Tunnel Avenue, a small furnished house that we rented while the owners were away. It was on the main road to the Blackwall Tunnel and right opposite the British Oxygen works, which started up at 5am every morning with a fearful clanging as they threw empty gas cylinders about. I travelled up to town from the nearby Westcombe Park Station to Waterloo and from there on another train to Battersea. After 6 months (in September 1951) we moved into a furnished flat (147 Croydon Road, Anerley) which was just being vacated by Jim Laker, the Surrey and England cricketer, who was off on an overseas tour.

1951 was also a big year for me at work. I was made a Senior Lecturer at Battersea, and also appointed a 'Recognised Teacher' of the University of London. Places like Battersea Poly (and Chelsea and Woolwich, etc) counted as Internal Colleges of the University, and had to have some of their staff approved as Recognised Teachers, who counted as members of the Faculty of Science, and were eligible to be University Examiners. My first appointment as Examiner for the University was as Examiner in Physical Chemistry for the B.Sc. Chemical Engineering degree, which I did for 3 years (1951-3).

I had acquired my first Ph. D students in 1949, Franz Hirschler a German refugee who got his Ph.D as a full-time student under my supervision in 1951, and Cyril Dulin, an evening student who took the statutory 4 evening years and got his Ph.D in 1953. Franz is now head of a precious metal dealing firm in London (in which he had family connections). Cyril Dulin, who became a great friend of ours, went on to do postdoctoral work at the University of Southern California before joining Du Pont's in the USA and becoming involved in the early work on single crystals of silicon and germanium for transistors.

In September 1952, I went to Canada with the Faraday Society for a conference in Toronto on Heterogeneous Catalysis, one of the subjects I was interested in. In those days we went by boat each way, from Southampton up the St. Lawrence to Quebec, and back from Montreal to Liverpool. The St. Lawrence Seaway had not been built then, so Montreal was the furthest up the St. Lawrence that the big boats could go - nowadays they can go right up to the Great Lakes. All travel within Canada was by train, and in addition to the conference, I gave talks at Laval University in Quebec, McGill University in Montreal, and the National Research Council in Ottawa.

Fog research

From September 1952 onwards Mum and I spent nearly a year at 11 Vincent Road, living with her Mum and Dad, who were very kind to us - regular visits to Charlton Football Club, of whom they were keen supporters, were a feature of the winter months. I travelled up to Waterloo on the train from Woolwich Arsenal, and from there on down to Battersea. There were some terrible fogs that winter where the visibility was literally less than ten yards, and they were sulphurous and choking from smoke from domestic fires. In one particular fog in London in December 1952, 4000 people died from lung problems attributed to the fog, which lasted for several days.

I got involved in the research then going on to try to reduce the impact of fogs in towns, and the parallel problem of dispersing fog on airfields. I published one or two papers, and in 1953 got two grants - one from an industrial company (Leda Chemicals), and the other from the Ministry of Supply (later Ministry of Aviation). I became involved, with some of my research students, in measuring properties of fogs so that we could understand them better, measuring size of water droplets, smoke content, sulphur dioxide and so on, and eventually' in 1954l the Ministry of Supply made me Director of a newly-formed Fog Research Unit, located at Battersea, and with a new laboratory and fog-chamber being built at Woolwich Arsenal.

In August 1953 Mum and I had moved to Dolphin Square, a large block of flats on the Chelsea Embankment, Pimlico. Mum knew old Mr. Castle, the Managing Director from her teaching connections, and we had been on the waiting list for some time. War-time rent restrictions were still applicable. We had a 1-bedroom, 1-living room, kitchen and bathroom flat - 101, Howard House, Dolphin Square. It was less than two miles from Battersea, on the other side of the river, so I usually used to walk there, or take a bus in bad weather.

Having spent a long time living in Woolwich and commuting to town, I was now living in town and commuting to Woolwich quite a bit (usually twice a week during term, and more during holidays, supervising the work in the new Fog Lab. there). By the time we had it finished it was the biggest cloud/fog chamber in the world, 27,000 cubic feet and instrumented for every kind of measurement. I had a couple of Ph.D. students (Dai Griffiths and Bob Picknett) working on the project, plus Don Benton, one of my ex-students who had done a Ph.D with me, then done 2 years post-doc research at the Canadian National Research Council in Ottawa. We then needed a technical assistant, and I got Ron Chamuffin to take on the job he proved absolutely invaluable because he could turn his hand to anything, from knocking up odd bits of apparatus, to arguing with civil servants, to hiring aeroplanes, etc.

On 22nd August to our great delight our first child Jane Laura Rosemary was born at Westminster Hospital. We continued to live at Dolphin Square until Jane was two, but a big block of flats like that was not the ideal place for a small child, so in 1957 we moved to 25 Romney Road, which was a four-bedroomed detached house (cost £4,000!) with a nice garden. I started commuting again, this time from Malden Manor Station to Battersea and to Woolwich.

In January 1956, just short of my 31st birthday, I was awarded my D.Sc. for contributions to colloid science, and that summer I did a lecture tour in the USA and Canada, talking about fog research and general colloid chemistry. In 1957 I was appointed Reader in Applied Physical Chemistry at Battersea, and I was also offered a job as a Senior Research Officer at the National Research Council of Canada, partly as a result of the lectures I had given at NRC in Ottawa the year before. We very nearly decided to

go - we had our medicals and everything, but family ties eventually kept us in England.

The fog work was still going strong - we concentrated mainly on the basic characteristics, and what made them stable. We had a mobile laboratory in which we could get to where the Meteorological Office told us a fog was going to be and, assuming that the fog materialised (which it didn't always), we could make our measurements and take them back to the lab for processing. I did some work with B.J. (John) Mason who was in the Department of Cloud Physics at Imperial College, and published a paper with him on fog stability and characteristics. He later became Director-General of the Meteorological Office, and was knighted for his work on the computerisation of weather forecasting. We looked at various methods of fog dispersal on airfields, having already decided that the sheer size of a London fog made it impractical to attempt dispersal. One square mile of fog 100ft. deep weighs about 200,000 tons, so the weight of a fog over greater London works out at hundreds of millions of tons. People used to write in and suggest setting up giant fans to blow the fog away, but it would need more than the energy of a fair-sized atomic bomb to shift that lot! The only way of reducing the town fog problem was to ensure that less soot and less sulphur dioxide went into the air, because these contaminants not only made the fog denser and more potentially lethal, but actually made it more stable. We were involved in the debate leading up to the Clean Air Act, and the introduction of smoke-free zones, which ended the days of the pea-souper fog.

On an aircraft runway, there are various practicable (but not necessarily economic) methods of clearing a fog for a limited period. These include (a) applying heat by burning kerosene in special burners along the runway, an increase in temperature of about 2 – 3 degrees Centigrade being required to get the fog to lift; (b) supercooled fogs or 'freezing fogs/ can be precipitated by seeding with silver iodide (as with rainmaking); (c) because the fog droplets contain an electrical double layer inside their surface, they can be persuaded to coagulate by spraying a dilute solution of a cationic surface active agent (i.e. a special kind of detergent) into the fog - provided that it can be distributed efficiently. The heating method was of course used in a crude form during the war (FIDO - fog, intensive dispersal of) and saved many bombers returning to fog-bound bases. (One commercial FIDO installation was built after the war, at Los Angeles International Airport, which I visited in 1956.)

Don Benton, Ron Chamuffin and I were doing flight trials at Bembridge Airfield in the Isle of Wight, the flying being done by Desmond Norman, who together with his business partner and designer John Britten (whom we also knew) later became famous for the Norman-Britten Islander and other Short Take-0ff and Landing (STOL) aircraft. When no fogs were available, we worked with clouds, which are rather similar but generally much cleaner! However in late 1957, Government interest in fog dispersal began to lessen because of the development of the first reliable blind-landing systems on aircraft. Nevertheless funding continued, and a lot of the data which we gathered then are still valid today.

British Baking Industries Research Association

In December 1957 I was offered a new job - at twice my existing salary - and in an entirely different scientific field. Because of my published work in colloid science, which deals with the properties of dispersions, e.g oil in water (emulsions), air in water (foams), water in air (fogs), etc, the Council of the British Baking Industries Research Association (BBIRA) invited me to become their Director of Research and Chief Executive. Bread, cakes, biscuits, doughs, etc are all colloidal materials, and they wanted me to apply what were then some new scientific ideas to an old trade. The initial drawback was that the BBIRA laboratories were located at Chorleywood in Hertfordshire to the North-West of London, whereas New Malden, where we were now living, was South-West of London and over 40 miles away. In the days

before motorways, it was a difficult and tortuous journey between the two, and we should obviously have to move.

I started work at Chorleywood in May 1958. Then on August 8th 1958 our little family was made complete by the welcome arrival of our second child, Diana Theodora Christine (born at 25 Romney Road).

When Diana was about 3 months old, we sold the house, and Mum and the two children went to live with the grandparents in Woolwich, until we moved into a brand-new house at 134 Highfield Way, Chorleywood (cost £4,100) in April 1959. The interval between Romney Road and Highfield Way seemed a long time!

The scientific work at BBIRA was interesting. Working with a team including Douglas Axford, Roy Knight, Bill Collins, and later Norman Chamberlain, John Ewart and others we began looking at the fundamental properties of wheat flour components, especially starches, and proteins, using new techniques which were only just becoming available (but are quite normal now), including gel electrophoresis, radiotracers, and, later, differential scanning calorimetry and electron spin resonance. We also studied the basic reactions which occur during the baking process and in other phenomena such as bread staling, mould growth, etc.. Over the years we published quite a lot of papers in scientific journals on topics such as these.

After two years we were able to put forward an entirely new breadmaking process - the Chorleywood Bread Process (CBP) - which within a few years was adopted by virtually every bread baker in the UK and by many abroad. It also led to the much greater use of home-grown wheat, and a large reduction in imports of expensive Canadian and American wheats.

Although it's a bit technical, it may be interesting to have a brief explanation of how the CBP works and why it had such a big success. Bread is made from flour, yeast, salt and water (plus sometimes optional ingredients such as milk powder or sugar). The characteristic of wheat flour as opposed to oats or barley is that it forms a dough that is elastic, and can be expanded by carbon dioxide produced during fermentation, and later by steam in the oven, without collapsing. The elasticity comes from the special properties of the protein in wheat (a mixture of many different proteins, known collectively as gluten). A wheat grain , after its husk is removed, consists of about 70% by weight of starch (in the form of granules), 14% of water, 2% of fat, 2% of sugars and between 8% and 15% of protein, depending on the wheat variety and the conditions under which it is grown. Low protein wheats are not much use for breadmaking and are used mainly for making biscuits and cakes for which elasticity is not required. High protein wheats give elastic doughs and are good for breadmaking. Before the invention of the CBP, a typical British wheat would have been 9-10% protein and it was usual to mix this with a high-protein Canadian wheat (say 15% protein) to produce a flour with about 11-12% protein to give a good elastic dough.

The doughmaking process used before the CBP was essentially a mechanised version of a system which had been used for many centuries. The ingredients were mixed together and allowed to stand in big bowls (each containing about half a ton of dough) for about 3 hours. During this time the yeast acted on sugars and broken-down starch to produce carbon dioxide (and alcohol), which caused the dough to rise. Also during this time the dough developed from its initial crumbly mass to a smooth elastic dough which could hold gas. This happened as follows:- in the wheat grain, roundish starch granules are packed in with protein filling the gaps between them. The protein molecules are shaped like little

springs, but in the packed form each spring is prevented from opening by chemical bonds holding different parts of the molecule together (these are called 'disulphide bonds').

In the old-fashioned process, known as bulk fermentation, the individual proteins are unsprung by enzymes which break the disulphide bonds, enabling each protein molecule to spread out and join up with others (helped by re-formed disulphide bonds). This forms a network which is elastic and gives the dough its breadmaking characteristics - i.e. the dough can rise during fermentation and in the oven, holding the gas in, and the expanded structure is eventually stabilised at high temperature, which prevents the loaf from collapsing. The formation of the network during bulk fermentation is a slow biological process which takes some hours to complete.

At BBIRA Douglas Axford, John Ewart and I published several papers on the structure and composition of gluten and on the changes which it undergoes during fermentation and baking. It became clear that of all the different bonds within a protein molecule (between carbon atoms, nitrogen atoms, hydrogen atoms, etc.), the disulphide bond (between two sulphur atoms) was the weakest, i.e. it required the least energy to break it. This led to the thought that if one took a newly-mixed dough and subjected it to very intense mechanical working, i.e. stirring/mixing/shearing (enough to raise the temperature by about 20 degrees Fahrenheit in one minute), it should be possible to break a lot of the disulphide bonds in it and thus permit many protein molecules to uncoil. If at the same time one added to the dough a substance which would encourage the re-formation of disulphide bonds to form a network (in this case we used ascorbic acid - Vitamin C), the whole doughmaking process which took 3 hours could be done in about 3 minutes. We tried it - and it worked!!

Splendid bread was produced straight away in the initial experiments, better than that produced conventionally. A lot of experimental work established that the optimum work input was about 40 joules per gram, and this could be controlled by suitable electrical equipment. However, if one was going to translate that to large-scale commercial production of several tons per hour, dough mixers would be required of a type that did not exist - powered by 50 or 100 horsepower motors. We managed to find an engineering firm (Tweedy Engineering) which produced high-powered grinding and waste disposal machinery. They had never made a doughmixer, but we managed to persuade them that it might prove lucrative, so they produced a one-tenth scale prototype and control gear for us. We gave the first big demonstration to Lord Rank (J. Arthur Rank of film fame - Rank Xerox - Rank Hovis Macdougall - British Bakeries, etc). He was so impressed that he ordered 6 full-scale machines for his bakeries (he had about 200) - and the process was off. Tweedy are now the biggest manufacturers of doughmaking machinery in the country, and they sell also all round the world.

As is usual with new inventions, many people thought that it would not succeed. It was said that bread made by the CBP would not taste the same, but we did research to show that the flavour substances were formed in the oven and not during the fermentation. We also held taste panels at meetings of master bakers and showed that they could not tell the difference between CBP and conventional bread. Another criticism (mostly from the media) was that CBP only produces 'cotton-wool bread, but the fact is that given a CBP dough you can bake it thoroughly to give a crusty loaf, or bake it lightly to give a soft loaf. Scores of different types of bread are now made commercially by CBP (representing over 90% of total commercial production), including white, brown, wholemeal, crusty or soft, etc. And you can buy frozen doughs (made by CBP) to bake fresh at home.

As the CBP was introduced into the industry, many changes took place. Millions of pounds worth of

heavy steel dough bowls became redundant, and new bakeries when they were built were much smaller than the old ones because tons of dough did not have to stand around fermenting for hours. The savings from this were partly offset by the costs of the high-speed mixers involved.

However, all these considerations were over-ridden by two enormous advantages of the CBP. The first arose from the fact that during the old bulk fermentation process about 4% by weight of the flour (sugars plus some starch) was fermented away and went up the chimney as alcohol and carbon dioxide. So the CBP, which virtually eliminated this loss, increased the yield of bread by 4%, a big commercial asset. Secondly, the CBP allowed the production of top-quality bread from lower-protein (and hence cheaper) flour. This was because, during the bulk fermentation process, enzymes called proteases (naturally present in the flour) broke down some of the protein during the 3 hours, so that at the end of that time a flour which had started at say 11% protein had a useful protein content of only 10%. With the CBP one could start with a 10% flour straight away. This led to big financial savings for the industry, and for the country as a whole. In the course of the next few years imports of expensive high-protein Canadian and American wheats fell rapidly, and far more English and other European wheats were used. In due course, special new English wheats were developed for use with the CBP.

All of our efforts were recognised in 1966 when in the first-ever list of Queen's Awards to Industry, BBIRA became the first-ever laboratory to receive one for the invention of the CBP! The Award was presented to us by the Lord Lieutenant of Hertfordshire at a special ceremony at the lab. And now, over 30 years later, it is estimated that the CBP has reduced the import bill from North America by a total of about 5 billion pounds.

During all this time I did a lot of travelling and gave lectures on proteins, starches, the CBP, bread staling etc. in USA, Canada, Australia, New Zealand and Europe. I was appointed to the Executive of the International Association of Cereal Chemistry, which met regularly in Vienna, and other places including Moscow and East Berlin during the depth of the Cold War.

I was also offered one or two jobs, which I did not accept as I was happy where I was; these included the Directorship of the new Food Research Institute at Norwich, and the Directorship of Scientific and Regulatory Affairs at Mars International in the USA. Lord Rank asked if I would be interested in becoming the Research Director of Rank Hovis Macdougall at their Cressex Laboratory in High Wycombe, but although this would have meant a big step up in pay it would have involved a narrowing in scientific opportunities, so I said no.

Flour Milling and Baking Research Association

Then in 1967 BBIRA merged with the Research Association of British Flour Millers (RABFM), and I was asked to become the Director and Chief Executive of the merged organisation, which was named FMBRA, the Flour Milling and Baking Research Association. The Director of RABFM, Dr. Moran had reached retirement age, and it was logical to bring the two organisations together in view of their overlapping interests. The RABFM laboratory (the Cereals Research Station) was located at St. Albans, and had a solid reputation for research into wheat structure and properties, milling technology, nutrition (especially iron, amino-acids and vitamins) and toxicology (especially of flour treatment agents such as agene and chlorine dioxide). I already knew something about wheat structure and milling technology, but I had to learn more about nutrition and toxicology fairly quickly, as a debate was developing at that time about the nutritional value of bread (including the statutory addition of iron, calcium, vitamin B1 and nicotinic acid), and about the safety of some of the additives used, such as

preservatives and flour treatment agents.

For the next few years, I spent a lot of time shuttling between Chorleywood and St. Albans. In May 1967 we moved from Highfield Way to Green Nook, Bridle Lane, Loudwater. I became involved with Government-sponsored research on the uptake of iron from bread, and on the efficacy of various forms of iron as nutritional additives, e.g. elemental iron, ferrous sulphate, ferrous ammonium citrate, etc. This involved work with radiotracers, and also feeding trials with anaemic and non-anaemic people. Things were complicated by the fact that it was not just the type of iron which determined how much was absorbed by the body. For example, if you took a given form of iron in bread as part of a meal rich in ascorbic acid, the absorption of iron was increased, whereas if the meal included an egg, absorption was decreased. The investigation of all this was interesting, but beyond the scope of this book, as they say. Other nutritional studies included work on the aminoacid composition of proteins in the various anatomical sections of the wheat grain, and on the breakdown of ascorbic acid during the baking process. With regard to additives, we looked at the toxicology of chlorine-treated flours, used in cakemaking, and the chemistry of the interaction of chlorine with flour. And we also got involved with new developments in milling technology, such as air classification of flour, and the development of automation in flour mills.

The miller and baker have to deal with a biologically-variable raw material, yet try to use it in a closely-controlled mechanised process. We worked on development of improved testing methods for protein quality, incipient sprouting due to a wet harvest, heat damage from over-drying, etc. At each harvest we examined hundreds of wheat samples and advised the industry on probable quality trends. And we collaborated with the National Institute of Agricultural Botany and the Plant Breeding Institute in evaluating new wheat varieties as they were being developed.

There were more lecture tours in the USA, Canada and Europe, and I was awarded a Silver Medal by the Royal Society of Arts for a lecture which I gave to them on the science of breadmaking. Then in 1969 it was decided to concentrate all FMBRA work onto the Chorleywood site, and to sell the St. Albans site. This involved quite a bit of work, not least in overseeing the designing, planning and construction of a large new wing to take the staff and research facilities from St. Albans.

Ministry of Agriculture Fisheries and Food

This was well advanced, but not quite finished, when I was approached in 1970 by one of the Under-Secretaries at the Ministry of Agriculture Fisheries and Food (MAFF), who had been deputed to ask if I would take on the job of Chief Scientific Adviser (Food) to the Minister, and to MAFF and Government Departments in General. It meant taking a wider role, and leading a team of people at MAFF covering every aspect of food, including legislation, policy advice and research on food chemistry, biology, microbiology, nutrition and toxicology, plus defence aspects, and so on. I would also have a multi-million pound research budget with which to commission research within MAFF and in outside laboratories. After a lot of thought, and talking it over with Mum, I decided to do it although it would be a terrific challenge, with no extra pay!

I left FMBRA with regret as I had made some good friends there and we had done some fascinating research together. One consequence of shifting to MAFF was that I changed a five-minute drive to work in Chorleywood for an hour-and-a-bit's train and tube journey to MAFF's offices in Whitehall Place and/or Great Westminster House.

Becoming a Civil Servant meant entering another world. Cabinet Ministers each run big Departments of State like MAFF, or the Foreign Office or Trade or Education or Health. They are each assisted by several Junior Ministers, depending on the size of the Department. Under the Minister (called Secretary of State in some Departments) are usually two Ministers of State (one in the Commons and one in the Lords) and two Parliamentary Secretaries (sometimes more). But Ministers and Junior Ministers come and go (average lifetime 1.5 to 2 years) as they are promoted or shifted to other Departments or dropped. And of course a General Election in which Conservative replaces Labour or vice versa means a complete change of Ministers.

Ministers and Junior Ministers rarely have time to learn all the details of the work in their Departments. Some are not really very interested in it, because they are only interested in climbing the tree up to more powerful positions, but they are responsible to Parliament for what goes on in their Department. They have to take part in Parliamentary debates, and to answer Parliamentary Questions. They also have to fight their corner for funding in Cabinet, appear on radio and television, represent the UK in Brussels, make overseas visits, and give speeches to Party conferences, Trade Associations, etc. For all these things they are given written and verbal briefings by their civil servants, especially the senior ones, and virtually all of their non-Party speeches are drafted for them.

The 'Official' (i.e. Civil Service) side of the Department is run by the Permanent Secretary, usually a person of considerable intellect and strength of character who has come up the Civil Service ladder, often with spells in other Departments, including the Treasury and the Cabinet Office. He, like most top administrative Civil Servants, is likely to have a degree in Classics or History from Oxford or Cambridge. They would claim that their skill lies in knowing how to run a Department, understanding the machinery of Government, seeing a broad view rather than a narrow specialised one, being able to persuade and influence important people, and knowing how to ensure that Ministers follow the correct policy lines, i.e. those put forward by the Permanent Secretary! He will be assisted by a number of Deputy Secretaries and Under-Secretaries, who are usually all travelling up the same route as the Permanent Secretary, although of course they will not all get to the very top. Virtually all these top people will have spent the whole of their working lives as Civil Servants. They comprise most of what is known as the Open Structure in the Civil Service (said to be so called because it is almost totally closed!). The remainder of the Open Structure consists of the top specialists in the Civil Service, such as doctors, scientists, engineers, etc., who supply the technical know-how at high level and are usually directly responsible to the Permanent Secretary, with access to the Minister (as I was).

When I first joined MAFF in January 1971, the Minister was James Prior, a member of Edward Heath's Cabinet; he later became Lord Prior, and Chairman of GEC. I had known him before, and had had dinner with him at the House of Commons a year or two previously, since as a farmer he was interested in the CBP and its impact on farming. The Permanent Secretary was Sir Basil Engholm, a tough bird who was respected but not loved; after his retirement he became Chairman of the Royal Opera House, Covent Garden.

Mercury scare

I was responsible initially for about 100 scientists within MAFF (later about 400 - 500).On my first day, I had hardly got into my office, met my new secretary Daisy Fisher, and started on my bulging in-tray, when I was summoned to meet the Minister and the Permanent Secretary. The previous week (Christmas week) there had been a big scare in the USA and Canada about the occurrence of high levels of mercury in fish, especially tuna. Mercury, particularly in the form of methylmercury which can occur

in fish, is a neurotoxin, and there had been some well-publicised cases of mercury poisoning (including deaths) in Japan, especially with fish taken from Minamata Bay, which had been contaminated by industrial effluent. However, the human body has defence mechanisms against methylmercury, as it does against most toxic substances, and it would only prove harmful if it were ingested in amounts large enough to swamp the defence mechanisms. I was given the job of straightaway setting up and chairing an Inter-Departmental Committee to establish the average intake of mercury of the UK population, to look especially at any vulnerable groups such as children or old people, and to look at heavy consumers of fish, including fishermen and their families. I went straight out of the Minister's office to a press conference which had been set up to show the press that the matter was under control, and then went off to telephone the Department of Health, the Department of the Environment, Scottish Office, Laboratory of the Government Chemist plus a few others to set up the first meeting of the new Committee. It took place the next day - so that the Minister could reply to a pre-arranged Question in the House on 19th January, to say that a Committee had been set up and had been working on the problem for some time!

Purchasing teams were organised to buy food in centres all over the country - London, Liverpool, Edinburgh, Belfast, Cardiff, Torquay, etc - in amounts corresponding to the average consumption in those areas as indicated by the National Food survey. The foods were classified in groups - cereals, meat and fish, green vegetables, etc (over 3,000 samples in the first study), and analysed by the Laboratory of the Government Chemist (LGC), by MAFF laboratories, and by others, and all the data brought together to estimate the intake of mercury by the average person. It was shown that the mercury contents of the major foods in the national diet were extremely low, and that the average contents in most canned and fresh fish and shellfish were also low, but higher than in other foods. Knowing the amounts of individual foods eaten by the average consumer we concluded that the average intake of mercury from food was about 7 to 8 micrograms per day, and that about 2 micrograms per day came from fish. We also found that fish from some coastal areas (especially Morecambe Bay where there was a source of mercury from industrial pollution) contained higher concentrations of mercury, up to 0.5 parts per million. Considering a hypothetical fisherman working exclusively in Morecambe Bay, and eating his own catch in amounts 4 times the national average fish intake, we came up with a maximum intake of methyl mercury from fish of 50 micrograms per day. (While all this was going on I visited USA, Canada and Sweden where similar studies were in progress.)

The information was submitted to the Department of Health's Committee on Medical Aspects of Food Policy (COMA), of which I was a member. COMA concluded (on the advice of one of its specialist sub-committees) that intakes such as this would be below the accepted threshold of neurotoxic effect. To be on the safe side we looked at the mercury contents of blood and hair of fishermen from polluted areas and their families and found no signs of elevated levels compared with "normal" people. A report was written for the Minister, concluding that there was no need to recommend that the general public should change its fish-eating habits. The full Report was published by HMSO, less than 6 months after the original panic. A follow-up Report, with a lot more analytical data, but basically the same conclusion was published in 1973, by which time we had published a similar report on lead in food, and were working on a report on cadmium.

I have described the mercury in fish problem in some detail because it was typical of the type of food contamination problem that was always coming up, and was always taken seriously. The Working Party on Mercury in Food soon became the Working Party on Heavy Metals in food, looking at lead, cadmium, nickel, etc.; and eventually developed into the Steering Group on Food Surveillance (which I chaired), looking at heavy metals, pesticide residues, fungal toxins, packaging migrants, nitrosamines,

radionuclides, etc. Usually after months of work the initial scare proved negative, but sometimes a result came up that we were not looking for.

To take one example, the study on levels of lead in food (which we published in 1972) threw up the fact that the average lead content of canned baby foods was much higher (2 or 3 times) than the average lead content of food eaten by adults, and this was traced to the use of lead-based solders in the can-making. After discussion with the Minister (and before the information was published), the baby food industry - including giant firms like Heinz and Metal Box - were called in and told (by Basil Engholm with me to back him up) that they would have to withdraw from sale all canned baby foods, and move over to jars, or cans with tin-based solder, or some other form of packaging. They did not like this as it represented a considerable financial loss, but they had to agree, and I appeared on the 6 o'clock BBC News on TV to announce the results and to say that all canned baby foods had been withdrawn and would be replaced by safer products. I also explained that there was no evidence of harm to children's health, but the action was a precautionary one, based on the known fact that infants are more sensitive to the neurotoxic effects of lead than adults.

Bacon scare

Needless to say other things were going on at the same time as the events which I have just described, and I came to think of my job as being rather like a juggler's, keeping a large number of soup-plates in the air at the same time, and hoping not to drop any of them. In mid-January 1971, when I had been at MAFF for 2 weeks, I was summoned to the Minister's office to meet Lord Trenchard (the son of the original Lord Trenchard, who had created the Royal Air Force in 1918). He was a Director of Unilever, the giant multinational company that owns firms like Wall's, Birdseye, Stork , Flora, plus vast interests worldwide in detergents, cosmetics, toothpaste, plant-breeding, animal feeds, etc. He had asked to see the Minister (James Prior) by himself "with no civil servants present" as he had some very confidential information to impart. But James Prior did not like the sound of this and said that Basil Engholm would have to be present. Lord Trenchard said it was a scientific matter which Basil Engholm would not understand, but he agreed that I could be present with the Minister.

Lord Trenchard told us that Unilever scientists working in their main laboratory at Colworth House in Bedfordshire had detected the presence of dimethylnitrosamine (DMN) in cooked bacon - not only in their own product, but in all of their competitors' products as well. I knew why he was worried, because DMN and other nitrosamines are powerful carcinogens (causers of cancer) in every animal species investigated, and probably in man as well. I asked how much was present, and he said a few parts per billion. The Minister asked what ought to be done, and my advice was to say nothing in public until we have confirmed the results by studies in other laboratories; looked at other foods to see if it is a problem only with bacon; found out how DMN is formed in bacon; got an assessment of possible risks to man; and looked for methods of getting rid of or reducing it. That same afternoon I was driven up to Colworth House, together with Lord Trenchard (with whom I later became quite friendly). I talked with the Unilever scientists and studied their methods and results, then talked to the Government Chemist (Harold Egan) and the head of the MAFF Food Science Laboratories (David Macweeny), and got some experimental work underway. The techniques for analysing for DMN at these very low levels were in their infancy, but within a few weeks it became clear that the Unilever results were right. The DMN was formed during cooking by reaction between potassium nitrite (used in bacon curing, and an essential antibacterial agent) and protein breakdown products (amino-acids); there were some other forms of nitrosamine present as well. DMN was also found in some cured meats containing nitrite, and also (later) in some samples of beer and whisky.

After meetings with the Chief Medical Officer (Sir George Godber) and others, I drafted a very cautious statement (approved by Basil Engholm) for the Minister to make in the House in response to an arranged PQ, saying that tiny amounts of DMN were present in bacon, but that no evidence of risk to the population had been established; this got no attention from the media at all. COMA agreed that MAFF should fund a major study on rats at BIBRA (British Industrial Biological Research Association), feeding several different levels of DMN so that we could see if there was any effect, and then extrapolate it down to the incredibly low levels of a few parts per billion. And we had talks with the bacon industry, and set up experiments in various laboratories to explore the possibility of eliminating DMN by changing the curing technology without ruining the product or making it unsafe.

The answers to these various questions came out over a period of years. There is still a small amount of DMN in cooked bacon (but less than before), and the risks to man have been shown to be small in relation to the other risks of life, like crossing the road, walking downstairs, or normal exposure to cosmic rays. Still, at the early stages which I am describing, I was still in my first few months at MAFF!

Nutrition

Apart from risks to man from food, I was also responsible for advising on nutritional questions (needless to say I had a lot of help from specialist colleagues - but it was my responsibility if anything went wrong). I became a Scientific Governor of the British Nutrition Foundation, and also became a member of the National Food Survey Committee (NFS), of which I became chairman from 1978-85. The NFS is a statistical survey of food purchasing habits, started during the war and continuing ever since, being gradually refined and made more sensitive as it goes along. Its nutritional aim is to assess the intakes of different foods by the average member of the population and, knowing the composition of these foods, to calculate the intake of energy, protein, fat, carbohydrate, fibre, etc., plus the intake of a range of vitamins and minerals as a percentage of the Recommended Daily Amounts (RDAs) recommended by COMA. Summary reports are published quarterly, plus a detailed Annual Report of 200 pages or so. This also analyses data according to location, family size, income group, etc. The second purpose of the NFS is an economic one, looking at prices, amounts spent on different foods and their time-trends, and price elasticities of demand, i.e. how much changing the price of a given food alters the demand for it. These calculations are done by expert statisticians and economists in MAFF, but my knowledge of mathematics was helpful to me, especially when I became chairman, and had to oversee the editing of the Annual Report!

Nuclear industry

Another of my jobs arose from the fact that MAFF was one of the licensing Departments for all nuclear establishments, including nuclear power stations, reprocessing plants and nuclear defence establishments. There are strict controls on the amounts of radionuclides (radioactive elements) which such establishments can emit to the environment, because of possible hazards to man and to livestock. Depending on the expected route to man (air, water, food, etc), the Department of the Environment (DoE) and/or MAFF have responsibility, while the Department of Health are involved in advising on health hazards, and other Departments such as the Scottish Office may be involved locally.

As many nuclear plants, including Sellafield (a major emitter of radionuclides) are situated on the coastline and discharge waste to sea as well as up the chimney, one of the critical pathways to man is via fish and shellfish (and seaweed for some Welsh people who eat laver bread). I had a team of 4 nuclear

inspectors whose job it was to set standards for the licences which each installation had, and to monitor their compliance. Subject to the advice of these inspectors, I signed the licences.

The MAFF Fisheries Laboratories (for which I later also became responsible) used research ships to monitor the dispersion of radionuclides in the sea. In the case of Sellafield for example, this involved tracking the radionuclides up through the Irish sea, round the top of Scotland, and over to the edge of Norwegian waters, taking samples of sea-water and of various types of fish as they went. MAFF Food and Agriculture laboratories looked at radioactivity in milk, meat, and other foods, and in soil samples. There were various scares arising from small accidental emissions of radioactivity, but the big one came with the Chernobyl disaster in USSR in April 1986, after I had retired, when significant amounts of radioactive caesium were found in lamb in the Welsh uplands and other areas over which the main Chernobyl plume had passed. A ban was placed for several months on the use of sheep meat from specified areas.

International collaborations

In 1971, we were not in the European Community, but were preparing for our entry in January 1973. There were endless discussions about conditions of entry, some of which had a scientific content, such as food standards, environmental pollution, etc. I was involved in these in Brussels, Paris, Amsterdam, etc. Needless to say, I used to delegate a great deal of this to colleagues (some of whom are still my friends today - including Joe Hirons and Mike Knowles). Joe created a record by visiting Brussels 37 times in one year.

The UK also held twice-yearly Tripartite Meetings on Food and Drugs with the USA and Canada, successively in Washington, Ottawa and London. The UK was represented at these meetings by Sir George Godber (CMO), plus one of his top medical staff, plus me. The meetings usually lasted 2 days and were highly confidential; we told the Americans and Canadians about for example the latest problems in the National Health Service, and about food safety issues (lead, nitrosamines, radionuclides, etc.), and they told us about their latest discoveries. These included detailed accounts before they reached public ears of Human Immunodeficiency Disease (HIV), and Legionnaires Disease. We organised some joint work on the possibility of food-borne transmission of viruses such as HIV, but fortunately all the experiments proved negative. We also exchanged information on the use of high energy irradiation (e.g. with electron beams) as a method of pasteurising and preserving foods, and we organised joint experiments which showed that such foods were safe. However, when the process entered the public domain, it got a poor press, and has so far been little used, although it could make some foods a lot safer - e.g. chicken, which is often contaminated with salmonella food poisoning bacteria.

I also became involved as an adviser to the Food and Agriculture Organisation of the United Nations (FAO) in Rome, and the World Health Organisation (WHO) in Geneva, and later chaired various expert committees for FAO and WHO. These were mostly concerned with nutrition, food safety and food standards, covering problems not only in the developed world, but also of developing countries. As always, a lot of this work had to be delegated to the various specialists in Food Science Division.

I think that all of the things that I have described about MAFF so far happened, or started, in my first 12 - 18 months there. I had discovered why senior civil servants always looked harassed. Whenever a problem of any kind arises, the Minister and the Permanent Secretary want to know what it is all about. They usually need a preliminary briefing in writing on the same day that they become aware of the problem, with follow-up briefs until it has been put to rest. The Minister, or one of his Junior Ministers,

may have to answer a PQ, or make a statement in the house, or appear on radio or TV - and they have to appear knowledgeable on the subject, whatever it is.

Because so many of the problems which I met were concerned not only with food, but also with health, it was vital to work closely with the Department of Health and Social Security (DHSS). The CMO was very helpful, as was the Deputy CMO, Ed Harris, and other top medical people including Peter Elias and especially Frank Fairweather, with whom I established a close working relationship. Frank and I usually accompanied the CMO to Tripartite Meetings. I was involved in the DHSS COMA, and I got Frank involved in the MAFF Food Standards Committee (FSC) and the Food Additives and Contaminants Committee (FACC). He is a pathologist by training, and later became an Honorary Physician to the Queen. It was invaluable to have an experienced clinician like him with whom to discuss draft reports, research proposals, briefs to Ministers, etc. I made a point of bringing other distinguished medical people on to MAFF committees, another good example being Ian Macdonald, Professor of Physiology at Guys Hospital, who came on to the FACC. At the time of writing (November 1998), I am still working with Frank (on BIBRA) and Ian (on ILSI).

I also worked closely with the Government Chemist, Harold Egan, who ran a big analytical laboratory providing specialised services for Customs and Excise, Home Office (including drugs), Department of the Environment, MAFF and others. He was the official Referee Analyst for all forensic work, including murder, forgery, etc. I became a member of the Advisory Committee to the Laboratory of the Government Chemist (LGC) in 1973, and served on it for 12 years.

I also served on various inter-Departmental committees run by the Cabinet Office to try to ensure that different Departments knew what others were doing, and did not fall out too often. Some of these had a defence element, e.g. I was responsible to the Ministry of Defence for many years for maintaining the Food Defence Stockpile which was distributed in various big warehouses all around the country, containing emergency stocks of flour, margarine, sugar, biscuits, etc., all of which had to be inspected regularly, flour, for example, does not keep for ever, so there was a regular programme of selling off the older stocks, and buying in new ones to strict quality specifications. Going back to the Cabinet Office, there was a committee of Chief Scientists, chaired by Sir Alan Melville, at that time Chief Scientific Adviser to the Prime Minister. Sir Solly Zuckerman (later Lord Zuckerman) used to sit in on some of these meetings and I later got to know him well. He had been Chief Scientific Adviser to the Ministry of Defence, and although he was now supposed to be retired he still had an office in the Cabinet Office and was very influential behind the scenes.

There was a regular stream of Ministers at MAFF, including Jim Prior (Con), Fred Peart (Lab), Peter Walker (Con) and Michael Jopling (Con). Parliamentary Secretaries whom I liked included Jerry Wiggin and Peggy Fenner (both Con), and I also got on well with Earl Ferrers and Lord Belstead, both Ministers of State in the Lords, and both later (at different times) Leader of the House of Lords. In other Departments over the years I came in contact with Barbara Castle (Lab, Health), David Owen (Lab, Health), Sir Keith Joseph (Con, Education and Science), John Major (Con, Treasury) and Michael Heseltine (Con, Trade). One usually only met these if there was some sort of inter-Departmental problem going on.

In 1975 my name appeared in *Who's Who?* for the first time, and then in Debrett's *Distinguished People of Today* (!). In 1976 I was elected a Fellow of the Institute of Biology in recognition of the fact that I had perforce become knowledgeable in various fields of biology without actually being a specialist in any of them.

About this time, our work on nitrosamines in food showed that some samples of beer, and some samples of Scotch whisky, contained several parts per billion of dimethylnitrosamine (DMN). The products from some companies contained it, others didn't. We tracked it down to the use by the affected companies of malt produced by direct firing. Malt is an essential ingredient of beer and of malt whisky (and in many cases the best-quality whiskies had the highest levels of DMN). Malt is made by germinating barley and then roasting it in kilns to get the right flavour. The kilns can be heated in various ways; in indirect firing the heat is applied to the kiln externally, but in direct firing hot gases from the combustion of coal, gas or oil are actually blown over the germinated barley. MAFF scientists showed that oxides of nitrogen in the hot combustion gases were reacting with components of hordein (the barley protein) to give nitrosated amino-acids, which subsequently broke down to give DMN. So the answer was simple - get rid of direct-fired installations for malting barley. This was done, and the problem for beer disappeared quite quickly, but with whisky the problem was worse as the industry had seven years' stock (many millions of gallons) in hand, maturing in bonded warehouses. Our previous toxicological results at BIBRA had shown that at levels of a few parts per billion, risks to human health were negligible. The Department of Trade and Industry were worried about lucrative exports of whisky, especially to the USA. We told the Americans at the next Tripartite Meeting. Their initial reaction was to ban the import of Scotch whisky, but we pointed out that it was now possible to distinguish analytically between whisky from direct-fired and indirect-fired malts, so if they put a limit of say 1 part per billion of DMN on imports, it would ensure that the industry sent them only products from indirect-fired malts. They were happy with this, and the other types of whisky went to the UK consumer and to other export markets. Whisky and beer are now free from nitrosamines.

In 1976 I was elected a member of the Athenaeum Club, having been a member of the Savage Club for several years before that. These clubs, especially the Athenaeum, were useful for meeting other senior civil servants, university professors, overseas visitors, etc. The Athenaeum is at the corner of Pall Mall, close to Whitehall, and I used to go there for lunch quite a bit. It was renowned for what was known as 'schoolboy food', and you could often see an ambassador, or a bishop, tucking into sausage and mash, followed by prunes and custard. After he stepped down from being Prime Minister, Harold Wilson spent a lot of time there - smoked a pipe and drank pints of bitter. I never spoke to him apart from an occasional 'good morning'. Roy Jenkins was often there, even when he was President of the European Commission in Brussels - a very clever chap, but very conscious of his own importance. I used to meet Harold Egan there, and sometimes Frank Fairweather, and Martin Holdgate, Chief Scientist in the Department of the Environment. I also used to have lunch regularly with Malcolm Thain, Director of the Tropical Products Institute (TPI) of the Overseas Development Administration - I was on the TPI Advisory Committee for several years, and still keep in touch with Malcolm.

Toxin research

My involvement with TPI and LGC helped me with MAFF's work on aflatoxin, and later on other fungal toxins. This story started in 1960 when over 100,000 turkey poults and ducklings died over a period of a few weeks after eating feed containing Brazilian ground nut meal. This led to a concentrated search for the highly toxic material responsible, and within a few months LGC isolated and identified a particular strain of the mould Aspergillus flavus present in the groundnut meal. This mould when grown in the laboratory produced a group of toxic substances which were named aflatoxins (i.e. toxic substances from A. flavus), of which the most toxic was named aflatoxin B1. This was shown to be acutely toxic to animals (and, in one accidental outbreak in the West Indies, to man), and also proved to be the most potent carcinogen known, producing liver cancer in every animal species tested, with some indication

that it behaves similarly in man. When aflatoxin is fed to dairy cattle, a less toxic metabolite aflatoxin M1 appears in the milk. In the 1970s we used recently-developed analytical methods which could detect a few parts per billion of aflatoxin B1 to study the levels in the UK food supply. We found positive results in some samples of ground nuts (i.e. peanuts), and also in figs, Brazil nuts, pistacchio nuts, maize, wheat, coffee, etc with the highest levels in peanuts.

We worked closely with the Americans and the Canadians through the Tripartite system - the Americans found widespread incidence of aflatoxin in corn (maize) grown in the Southern states where the warm, moist conditions at harvest encouraged the growth of moulds. Also in the course of this work we and the Americans discovered several other mould toxins, or mycotoxins as they became known, including ochratoxin (in wheat, meat (kidney), and pulses), patulin (in fruit juices), and moniliformin (in maize). The Americans set about improving the hygiene at harvest and post-harvest for vulnerable crops in their own country, especially for maize and peanuts, two of their biggest crops in the South. We and they sent our inspectors out to Turkey to help them clean up their fig production. All our analytical results were published, and although it is not possible to eliminate mycotoxins entirely from the food supply, we agreed at the Tripartite, and later with the EEC, a regulatory limit of 30ppb, which was about the best that ordinary public analysts laboratories could do at that time (now down to 4 ppb). All import consignments of peanuts, figs, and other vulnerable products were sampled, inspected and rejected if necessary.

While the import inspection scheme was in its very early stages (about 1980), it led to one of my very few brushes with the then Prime Minister, Mrs. Margaret Thatcher. I was called to her room in the Cabinet Office just after she had got back from a Commonwealth Conference. Apparently Mrs. Gandhi, the Prime Minister of India, had buttonholed her and said that the UK were discriminating against Indian exports; she mentioned peanuts as a good example, saying that we preferred to get them from our good friends the Americans, who grew them in Georgia (Jimmy Carter, a Georgia peanut farmer was US President at the time!). Mrs Thatcher said that if this was true, it was unforgiveable, and who had advised the Government on this, implying that the person concerned should have his brains tested. Fortunately her first degree had been in Chemistry at Oxford, and as I explained the problem as outlined above she became quite interested. When I told her that about half of Indian shipments were over the limit of 30ppb, quite a few were over 100ppb, and one had been 440ppb, she accepted that what we were doing was necessary to protect UK public health. I suggested that we might send a MAFF expert out to India to help them clear up their crop husbandry and post-harvest handling of peanuts to reduce aflatoxin levels. This was agreed, and one of my chaps from Food Science Division (Trevor Coomes, who had previously worked at LGC) was sent out to India. After some uncomfortable months he managed to make improvements which have improved the quality of their products - but not up to the level of Georgia peanuts!

By about 1980 there had been various changes at the top of MAFF. The Permanent Secretary, Sir Basil Engholm, retired, to be replaced successively by Sir Alan Neale (ex-Treasury), Sir Brian Hayes (home-grown by MAFF) and Sir Michael Franklin (ex- Cabinet Office). Sir Charles Pereira became Chief Scientist on the Agriculture side, and was later succeeded by Bernard Weitz. One of the young Assistant Secretary-level administrators who was responsible to me at one time (John Holroyd - History graduate from Oxford) rose to great heights. He became Director of Establishments at MAFF, then moved to the Civil Service Commission as Second Commissioner, later becoming First Commissioner of the Civil Service - i.e. the person responsible for making all appointments in the Civil Service. He then moved into No. 10 Downing Street where at the time of writing he is the Appointments Secretary and Ecclesiastical Secretary - responsible for advising on top appointments like bishops or heads of nationalised industries,

and for overseeing the Honours system. I am still in touch with him and see him frequently at St. Albans Abbey, where he sings in a choir and is a lay reader.

I was still doing a lot of travelling in Europe and North America. Then in 1980 I was asked to give a series of lectures in Australia, and was able to take Mum with me (needless to say, not at public expense!). We visited Adelaide, Naracoorte, Melbourne, Tasmania, Sydney, Brisbane and the Barrier Reef, spent some time with Mum's Australian relatives and were away 8 weeks. Unfortunately, my father died, aged 85, while we were away, 17 years after my mother who died in January 1963, aged 62. I was very fond of them both.

The 1980s

1981 was another busy year. I was asked to take over responsibility for fisheries science as well as food, including a big laboratary at Lowestoft (oceanography, fish population dynamics, pollution of the sea, fish farming, etc.), plus medium-sized ones at Aberdeen (fish processing), Weymouth (fish diseases), Burnham-on-Crouch (special aspects of pollution) and Conwy (shellfish). I also became a member of the Council of ARC (Agricultural Research Council). The Chairman of the Council was Lord Porchester (who was also the Queen's racing manager), who had succeeded J. J. Astor, of the aristocratic Astor family (and owner of the *Observer* newspaper). The Secretary of the ARC was Sir William Henderson, later succeeded by Sir Ralph Riley. The ARC had many Institutes, most of which I visited, including one of which I later became Chairman. They included the Plant Breeding Institute, Institute for Animal Diseases, Rothamstead Experimental Station, National Institute for Research on Dairying, and many others.

I also joined the Council of NERC (the Natural Environment Research Council), because of MAFF's interest in many of its research areas. The Chairman of NERC was Sir Herman Bondi (mathematician, astronomer, big bang theory, etc., and later Master of Churchill College, Cambridge). He was succeeded by Sir Hugh Fish (an appropriate name), Chairman of Thames Water Authority. I and my colleagues became involved with research at various NERC laboratories including the Institute of Oceanographic Sciences, the Institute of Hydrology, the Scott Polar Research Institute, etc.

Together with my new fisheries responsibilities, I acquired a new right-hand man on that side, Malcolm Windsor (ex-Humber Laboratory), who was invaluable in briefing me on all the wide range of problems which cropped up. Malcolm later became Secretary-General of the North Atlantic Salmon Conservation Organisation, and I am still in touch with him.

Fisheries research

I became a member of the Fisheries Research and Development Board. As a result of the cod war with Iceland, the UK fleet of freezer-trawlers was largely being laid up. We managed to snap one up (the Arctic Privateer) reasonably cheaply as a replacement for our ageing research vessel at Torry in Aberdeen (there were also three reasonably modern research vessels at Lowestoft). Membership of the European Community meant a lot of work on assessing fish stocks in the North Sea and all around the UK, estimating Total Allowable Catches (TACs) for fish of various types in each area, and then trying to ensure that other EC nations did not grab more than their fair share. Strict specifications were developed on minimum mesh sizes for nets to ensure that juvenile fish were not taken; these rules were enforced in the UK, but not in many other countries. The Danes in particular fished with excessively small mesh sizes and picked up lots of juvenile fish which went for animal feed. All this had a bad effect on the development of mature fish stocks, and led in later years to the temporary complete banning of

fishing in certain areas. Fishing quotas were introduced - each vessel or group of vessels was allowed to catch specified amounts of cod, herring, skate, etc - and again we enforced this, but others didn't. A lot of UK fishermen sold their quotas, i.e. the right to catch so much fish, to vessels from other countries, especially Spain.

We were also involved in the early days of fish farming, and research went on at Lowestoft (trout), Aberdeen (salmon), Ardtoe in Scotland (turbot), and Conwy (shellfish and lobsters). Trout farming was established first, and was quite profitable, especially in the early days, the main variety being rainbow trout (imported from the USA) rather than the native brown trout. Salmon farming was more complicated because salmon go through several different juvenile stages, and also they are migratory fish - left to themselves they leave their home river, go across to Greenland, and come back to spawn towards the end of their lives. The solution adopted in the U.K. and in Norway was to keep the salmon in big sea cages in sea lochs. At first, large profits were made because salmon was a very expensive fish, but as supplies increased, prices fell, problems arose with fish diseases and water pollution, and a lot of the smaller salmon and trout farmers were forced out of business. Other small-scale operations (but lucrative to the operators) included farming of eels in the warm-water effluents from nuclear power stations - eels are highly prized and expensive in Europe, especially in Holland. Shellfish farming has been known for a long time (especially oysters). Lobsters proved more difficult to farm because of their cannibalistic tendencies! In the 1980's about 1% of the U.K. food supply came from fish, and about 2% of that 1% came from farmed fish of all kinds.

In 1981 I was also appointed MAFF representative on the Advisory Board for the Research Councils (ABRC - Chairman Sir David Phillips), an elevated body whose job was to take the annual budget for science decided by the Government (some hundreds of millions of pounds), and allocate it between the five Research Councils - Medical (MRC), Agricultural (ARC), Natural Environment (NERC), Science and Engineering (SERC), and Economic and Social (ESRC) - plus some other bodies such as the Royal Society and the Fellowship of Engineering. As one might imagine, each recipient Council fought as hard as possible to maximise its share, and the meetings were interesting. Membership of the ABRC also took me to a variety of laboratories, such as the Laboratory of Molecular Biology at Cambridge and the Joint European Taurus (JET) at Culham.

University of Surrey

In 1982 I was appointed Honorary Professor of Biochemistry at the University of Surrey. The University was formed in the early 1960s, and was based on Battersea Polytechnic. Like many of the new Universities appearing at that time it was more narrowly based than the old Universities like Oxford, Cambridge and London, but had one or two first-class Departments as well as some reasonable ones. The Biochemistry Department at Surrey was recognised as one of the best in the country, and there was also a top-class Department of Satellite Engineering. Although I was busy at the time, I was happy to accept because (a) of my past links with Battersea; (b) common research interests in nutrition and toxicology; (c) I still had some old friends there, including Don Benton, who was now a Senior Lecturer. The job was not too onerous; I gave one or two lectures, helped with the supervision of some Ph.D students and did a bit of examining for Ph.D. (I should have mentioned before that since the early 1970s I had been an External Examiner at the Universities of Leeds and Nottingham for B.Sc., M.Sc. and Ph.D., so I had been keeping my hand in on the examining front.)

Companion of the Order of the Bath

All the usual problems, panics, meetings and travel continued, but one morning in May 1983 I received a letter from the Prime Minister's Office which said: "The Prime Minister has asked me to inform you, in strict confidence, that she has it in mind, on the occasion of the forthcoming list of Birthday Honours, to submit your name to The Queen with a recommendation that Her Majesty may be graciously pleased to approve that you be appointed a Companion of the Order of the Bath."
I had had no inkling that this was on the way, and needless to say was very pleased as the CB is normally the second highest honour to be given to civil servants, the highest being KCB to Permanent Secretaries and equivalent. So on 11th June, the Queen's Official Birthday, there was my name in the Honours' List - and on 26th July I appeared with Mum, Jane and Diana at Buckingham Palace for the investiture. Morning dress and top hat, as proved by photographs now on the wall. Back to work next day for a meeting of the ABRC in the morning, and a meeting with the Permanent Secretary in the afternoon to discuss research organisation and financing - i.e. back to reality!

Retirement – of a type!

By now I was coming up towards retirement - all senior civil servants are pensioned off on their 60th birthday, the theory being that (a) they should make room for new blood, and (b) they should still be able to do something useful after that! One sign of advancing years came in 1984 when I was awarded an Honorary Degree (D.Sc) by the University of Reading. One of the other people receiving an Honorary Degree at the same time was Lord Zuckerman, and another was Garry Weston, Chairman of Associated British Foods (ABF). Garry Weston is one of the richest men in England, a billionaire several times over, but still a decent (though tough) chap. He owns Fortnum and Masons, Allied Bakeries (Sunblest, Allinsons, Vitbe,and lots of supermarket own brands), Ryvita, Allied Mills, British Sugar, Burtons Biscuits, etc., plus companies in Australia, Canada, USA and elsewhere. He was getting his Honorary Degree for Economics. I had known him for some time, originally through Chorleywood, and as we shall see, I later became a consultant for him.

BIBRA, the British Industrial Biological Research Association, with which I had been involved for a long time (with the toxicology of nitrosamines, aflatoxins, food additives, etc,) held a special symposium on toxicology in 1984, which they kindly called the Elton Symposium in my honour - it was chaired by Lord Zuckerman, the President of BIBRA, and a number of people with whom I had worked presented papers. (A few years later I became Chairman of BIBRA, and then Vice-President.)

Meetings and travelling continued right up to the day before my retirement. Then a farewell drinks party, and on 27th February 1985 I qualified to draw my pension. However, as expected, work did not end completely - just slowed down a bit and changed direction. MAFF nominated me to be the UK representative on the European Commission's Scientific Committee on Food (SCF) in Brussels. This was just starting to set the basis for an EC-wide system of food safety and standards. Many of the problems which the SCF was tackling had been looked at before in the UK and other member states, especially Germany and Holland. These included the toxicology of food additives and contaminants, food irradiation, nutritional standards, etc - but because of different agricultural practices, food habits and

levels of enforcement in the 12 member states (later 15), getting agreement on uniform standards was not easy. The SCF met in Brussels (and occasionally in other cities such as Amsterdam, Berlin, Paris, etc.) about once a month and before each meeting I received about a kilogram of papers to study. After a couple of years I became Vice-Chairman (the Chairman was Dutch).

In 1985 I also became Chairman of the Food Research Institute (Bristol), an ARC Institute (by then AFRC - Agricultural and Food Research Council). This involved overseeing the general quality of the research there, much of which was concerned with meat, and dealing with financing and organisation.

During the summer of 1985 I received a surprise telephone call from Garry Weston, Chairman of ABF, and I visited him at his head office in Knightsbridge. He asked me to become scientific consultant to the Group on a retainer basis - and I accepted. The appointment was initially for a 2-year period, but was renewed for successive periods, and I did a total of 12 years with ABF. This included advising on problems in milling, baking, food safety, nutrition etc, and the job took me to Brussels occasionally and to various parts of the UK, mostly I took part in meetings at the main ABF laboratories (initially at Taplow). One of the first jobs was to help the ABF Chief Scientist (Bill Elstow) with the designing of a big new headquarters laboratory, which was built on the Vanwall Industrial Estate at Maidenhead, and became operational in 1987.

About this time I was made an Honorary Member of FMBRA, which kept me in touch with old friends and colleagues, and with the research going on there. Later FMBRA merged with Campden Research Association, and moved to Chipping Campden in Gloucestershire - where my old MAFF friend Joe Hirons is on the Council.

Caramel research

Another interesting experience, which was to have big after-effects, occurred in November 1985. The SCF in Brussels was looking at the toxicology of caramel colours used as food additives. Caramel is used to colour a wide range of foods and drinks, and the total tonnage used outweighs all other additives put together, since caramel is often used at thousands of parts per million. There are four types of caramel - Class I, soluble in alcohol and used in whisky, brandy, etc; Class II, used in ice cream; Class III, used in beer, stout, baking and catering; and Class IV, stable in acid solutions and used in soft drinks, especially colas. Toxicology studies had been done on the various classes at BIBRA and elsewhere, and although Classes I, II and IV were relatively clear, there was a question over the possible safety of Class III (ammonia caramel), which was used in thousands of tons per year around the world.

The main problem was that if ammonia caramel was fed in large doses to rats whose diet was deficient in Vitamin B6 it induced lymphocytopenia, i.e. a drop in the blood level of lymphocytes (one of the several types of white blood cell). This was traced to a particular component of caramel III, a complex imidazole known as THI, which arose from the reaction of ammonia (used in the preparation) with other materials formed during the high-temperature caramelisation of sugars. THI, once formed, was difficult to remove. Did this represent a hazard to man?

SCF tended to work by giving individual members the task of investigating particular problems and then reporting back to the main Committee with a recommendation and the caramel problem was given to me. Because the manufacture and use of caramels is such big business worldwide, the caramel industry is very well organised, and technical and scientific aspects are looked after by the International Technical

Caramel Association (ITCA) in Washington DC. The President of ITCA at that time was Dr. Alex Malaspina, Senior Vice-President of Coca-Cola International, in Atlanta. I had known Alex for some time, having met him at a meeting of the Toxicology Forum in Aspen, Colorado in the late 1970s. I telephoned him to cross-question him about caramel, and he immediately invited me over to Atlanta to see the data on all four caramel classes, and to discuss it with the two technical people concerned, both of whom worked for him. Although Coca-Cola and other soft-drink manufacturers used only Caramel IV, ITCA had to deal with all four Classes. In any case the soft-drinks industry were worried that if Class III were banned it would make all forms of caramel bad in the public's eyes. I went over to Atlanta and spent a week going through everything, especially the chemistry of the caramelisation reactions, which are complex. When I got back I wrote a paper for SCF suggesting possible solutions to the THI problem, and putting forward criteria for the acceptability of each of the four Classes of caramel. After discussion and further work, these were accepted and written into Community and UK law, and remain the standards for caramel today.

There were other similar problems at SCF, but the caramel one led on to work with Alex Malaspina on other questions, a long-term friendship, and an interesting link-up with one of Alex's other main interests, the International Life Sciences Institute (ILSI), of which he was (and is) the President.

ILSI had originally been set up by Alex and one or two others in 1977 in response to public concern about the safety of food additives. It received multi-million dollar support from the international food and drink industry, plus some from the pharmaceutical industry, but was governed by a Board dominated by academic scientists, including several Nobel Prizewinners. It started by commissioning major research programmes on the safety of caffeine, saccharin, and other food additives and components, and moved on into a wide range of health and safety issues, including food contaminants (chemical and microbiological), water quality, nutrition and environmental issues. It organised key conferences all over the world, bringing together the world experts in each particular field. It cooperated with the World Health Organisation (WHO) in Geneva and the Food and Agriculture Organisation (FAO) in Rome. All its results were published, either in scientific journals or in books in an ILSI series.

ILSI had its headquarters in Washington DC, and fairly soon Alex also set up ILSI Japan and ILSI Australia. At the time of writing there are branches all over the world, in every continent. Early in 1987 Alex asked me to help him to set up ILSI Europe in Brussels, and to become a member of its first Board of Directors. He also asked me to become a consultant to ILSI International, and to advise on their operations worldwide. I was happy to do this, especially as I would be working with another old friend, Professor Ian Macdonald, who had just become ILSI Nutrition Coordinator worldwide. Ian was one of the world's experts on carbohydrate metabolism, and had just retired from being Professor of Physiology at Guys Hospital. Setting up ILSI Europe was quite a task, although of course I was not the only one involved, and in the ten years that I was on the ILSI Europe Board, I travelled to Brussels a lot (as well as my travels there for SCF).

One of my jobs was to be Chairman of the ILSI Europe Working Group on Nutrition, and over the years we organised a number of ILSI Europe and ILSI International Conferences in various parts of Europe. The first was a conference on Radionuclides in the Food Chain which took place in Vienna shortly after the Chernobyl nuclear accident in USSR, which caused many deaths, and contaminated large areas of the USSR and other European countries. We managed to get the Russians to come and tell us (more or less!) what happened. Other conferences included "Diet and Health in Europe" (Brussels) and "Food, Nutrition and Chemical Toxicity" (Guildford). The proceedings of these and other ILSI conferences

eventually appeared as books.

The 1990s

Honorary degree from Surrey

In 1991 I was lucky enough to be awarded my second Honorary Degree - this time from the University of Surrey. They made me a Doctor of the University, which I received from the Chancellor, the Duke of Kent, at a ceremony in Guildford Cathedral. Other people getting Honorary Degrees at the same time included Lord Runcie (just retired as Archbishop of Canterbury) and Lord Rayner (then chairman of Marks and Spencer). Then the following year I actually collected my first degree (1944) at a special ceremony organised by London University for people who had graduated during the war. Vera Lynn was given an Honorary Degree at this ceremony to mark her war-time efforts, and entertained everyone with a few well-remembered songs.
In 1992 I retired from the Scientific Committee for Food in Brussels, but took on another job as consultant to FAO in Rome. One of my tasks was to help organise and prepare the papers for the FAO/WHO International Conference on Nutrition (ICN), which was aimed particularly at nutritional problems in the third world.

In 1993 I was elected Chairman of BIBRA, having been associated with its work for many years. We decided to shift the balance of BIBRAs toxicological work from mainly food components, additives and contaminants, to a 50/50 split between food and pharmaceuticals. The reasons for this were (a) the growing challenges of pharmaceutical work, especially with genetically-modified materials, and (b) the much greater funds now available from industry, Government and EU for pharmacological research. To support this new effort we built a 24-bed clinical unit, headed by my old friend Frank Fairweather, with Ian Macdonald as one of the advisers. We secured the cooperation of local GPs and hospitals and assembled a panel of several hundred volunteers of all ages to take part in the work. The clinical unit has proved very successful, and is now one of the mainstays of BIBRAs income. Before long, BIBRA will probably need to merge with one or more other laboratories in Europe in order to get the necessary critical mass for large-scale pharmaceuticals evaluation for the international drugs companies. At the time of writing, a link-up with TNO Pharma in Holland is being discussed. My Chairmanship of BIBRA ended in 1995, and in 1996 I was appointed one of two Vice-Presidents (the other being Alex Malaspina!). At present we have no President, following the death of Lord Zuckerman.

Also in 1996, I was asked by FAO to chair the FAO/WHO Expert Committee on Biotechnology. This would have involved chairing a series of meetings (in Rome) of the world's experts on this subject, and producing a definitive report covering all aspects of biotechnology, including genetic manipulation. This time, however, I declined because although it was a very flattering offer it would have required too great an investment of time. In any case, I was beginning to reach the age of retirement from at least some of my jobs. In 1997 I retired from the Board of ILSI Europe (after 10 years), from my Surrey Professorship (15 years), and from ABF (12 years). And in November 1998 I retired as a Scientific Governor of the British Nutrition Foundation (28 years).

But, at the time of writing, I am still working for ILSI - and still enjoying it!

G. A. H. Elton, December 1998