Behind the lab door: an inside look at how the Cawthron Institute survived and prospered, 1970-1992

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Preface

Much has been written about Cawthron, including an official history, but comparatively little of it has focused on what happened in its service laboratories. These were semi-independent of the research group and often instrumental in earning the income that was crucial to the institute's survival as it struggled to reinvent itself during the 1960s and 70s.

These are my memories of my time as manager of the commercial activities of the institute which stretched from April 1970 to 1992 and largely focus on the laboratory testing services we offered. As well as producing much-needed income, many of these services helped raise the public profile of the institute and in some ways provided a template for the development of science in NZ.

While I have spoken with Marylyn Cooke and Royd Thornton to help clarify events, the views expressed are my own and any errors are mine.

My thanks goes to Peter Watson, who helped with the editing, and to my fellow Cawthron staff members for their contributions and friendship over the years.

First impressions

In 1969 my wife Marylyn and I were working in London when we heard through friends there were two positions available at the Cawthron Institute in Nelson. We had been in London for three years but had decided to return to New Zealand because it was a better place to raise a family. I was at the drug company Parke Davis and Marylyn was at the Lister Institute but both jobs were about to end. The Lister Institute, like the Pasteur and Cawthron institutes, was a scientific research establishment individually endowed by one person. And like the Cawthron, the two European bodies were running out of money and forced to adopt commercial activities to survive so we had some inkling of what to expect when we did move. While at the Lister Marylyn became friends with Pat Barnsley, who was also a microbiologist, and later her biochemist husband Eric. They had moved to New Zealand in 1969 for Eric to take up a lectureship in biochemistry at Victoria University in Wellington and not long afterwards they wrote to us with details of dual vacancies at the Cawthron. We both applied and were appointed, arriving in Nelson in April 1970.

When we drove into the then new Cawthron grounds in Halifax St East in our 2+2 E-Type Jaguar, we were met by a somewhat surprised Dr Barry Cousins, the director of the institute. New scientists did not usually arrive in an expensive sports car but I maintained that it was an investment, and it was.

At this time the Institute was still partially based in Fellworth House on the hill above the present day site. It was raining and our meeting in Barry's office in the new building was punctuated by the plink of water dripping into buckets arranged to catch the leaks. Barry was tall, a chain smoker and not well but had a burning energy that seemed to keep him going. He was a biochemist who had spent some lecturing at the Dunedin dental school. He had also worked in the USA and still had the green Nash Rambler station wagon he had brought home. He was not to live long enough to see the official opening of the new building in December of 1970. A severe asthma sufferer, he had several stays in hospital over the winter, with Dr Mike Taylor taking over when he was away. In the end, it was too much of a strain on his heart.

While we did not know Barry for long, he did tell us of the transformation that was taking place at Cawthron and the struggle that he had faced in converting an old fashioned, destitute research institute into a more modern structure that might keep the Cawthron name alive. As he explained, Cawthron started in 1921 with a very large bequest from leading local businessman and philanthropist Thomas Cawthron and some smaller ones from others such as Isaac Hopkins. By my calculations, the Cawthron bequest of about £230,000 would have been worth about $26 million in today's dollars and was the largest single bequest in New Zealand at the time. It also had a considerable property portfolio which pushed its wealth to around $127 million. Back then Cawthron was said to be the second largest research Institute in the Commonwealth, smaller than only Rothhamstead in England. Cawthron focused on agricultural research and did so very successfully, but its capital had been invested in things like farm mortgages for very long terms of 25 years or so at low interest rates of 2-3 per cent so that inflation had significantly reduced the value of its investments.

When Barry Cousins took over in 1967-68 Cawthron had almost run out of money. I was told by then chairman Frank Archer that things were so bad they discussed closing the Nelson laboratories and using the remaining money to endow a chair of chemistry at Victoria University. The Government was considering stopping its annual grant paid for out of the DSIR budget mainly because it also thought the institute was doomed. Royd Thornton has told me his first job when arriving at the institute to take over from Barry was to prepare a case to the Government to justify the continuation of the grant.

The Cousins legacy

In a bid to save the Cawthron from closure, Barry had embarked on a dramatic programme of reform which involved:-

* Discontinuing most of the old lines of research and redeploying staff on new work.
* Recruiting new staff.

* Persuading the institute trust board to sell the remainder of its property investments, including Fellworth House and land on Observatory Hill, and building new laboratories on flat land behind the museum in Halifax St East. About $100,000 was spent on the labs, which were designed by an architect friend of Barry's.
* Offering commercial testing services to supplement the meagre income the institute received from its bequest investments and government grant. This was a major change as previous directors and boards had largely been against commercial work being done in a research institute, according to Barry. This new work included contracts to test wood chip exports, dairy factories in the top of the south region, soil from municipal sports fields, bowling greens and parks throughout the country and the establishment of a water and waste lab under Dr Mike Taylor to service the institute's own research scientists as well as municipal authorities, catchment boards and industry. In total it was earning the institute about $8000 when we arrived in early 1970.

Early work

When we arrived Eric Chittenden and Jack Stanton were still doing some tomato research in glass houses at the back of the new labs on land that had always been used for trial plots. As well as this, they had started to help researchers testing the quality of water in the Nelson Lakes National Park. Both had been active in the founding of the Mt Robert Ski Field and were very familiar with the area. I attended Eric's funeral where the story was recounted of him rowing a cast iron pot belly stove for the ski hut across the lake to the foot of Mt Robert and then carrying it on his back up to the new hut. Eric was not a very large person so it was a remarkable feat.
The only old staff member who came directly under my direction was Joyce Watson. Joyce did plant analyses mainly by wet chemical methods, which used almost no instruments, unlike today which often involves complex electronic equipment. A lot of her work involved tobacco leaf and hop analyses. This was principally to determine the nutritional status of the plant. Testing for alkaloids was also done on tobacco to gauge the nicotine and other alkaloid content. I still remember Joyce using her old Marchant hand-turned desk calculator to churn out the numbers. This calculator is now in the Nelson Provincial Museum in Trafalgar St.
Joyce also carried out a project involving newly rediscovered takahe near Te Anau. The birds were being limited by their poor food supply as they only ate the top of the roots of younger tussock. The project was to measure the levels of nutrients available to them and decide if a judicious application of fertiliser could improve their food supply. I believe that phosphorus and nitrogen were eventually applied to the tussock and the health of the birds improved significantly as a result. This work was commissioned by the Wildlife Service and I remember that we were paid from their horse feed account.
The only other old work being done was bitter pit research in apples. This mostly related to low calcium levels in the fruit and involved trialling calcium sprays.
I was decidedly uncertain just what a commercial laboratory did when I took over the small group of up to 10 people so it took a little while to come to grips with the work. Initially, I was viewed rather suspiciously by some of the old hands and in one case I don't think I was ever totally accepted. The change in direction of the institute was traumatic for many older employers who had been there a long time.
It was clear we had to make money or else and I tended to set prices at a full commercial rate with no favours or mates rates. At the beginning this was sometimes not a lot as people were unaccustomed to paying for this sort of work. Later charges were a little high at times but I maintained that they were supporting a good cause. In all

our work I always felt capable of doing any of it myself and worked closely with the analysts at a technical level. Microbiology was the exception and Marylyn kept an eye on this.
I soon worked out that commercial work was about large sums of money, not so much what we charged but the value of the goods we tested. For example, wood chips have a moisture content which varies according to how long the logs have been sitting around but the Japanese purchaser paid for dry wood. This meant we had to work out how much dry wood was represented in a boatload of wet wood. We carried out hundreds of measurements of moisture content taken as the boat was loaded and calculated the average water content of the full load, which was usually about 45 to 55 per cent. Just 0.01 per cent water represented many hundreds of dollars so both the buyer and the seller had to be confident we had the right answer. We were regularly audited by both sides and I do not recollect ever having a problem. Independence was essential.
It was this independence which was, and still is, the main asset of the institute. In New Zealand the Government sets the rules that industry has to abide by but for many years it was only the Government that had the expertise to determine if the rules were being broken. The arrival of Cawthron provided a reputable independent body that could side with an industry against the Government but still be part of its science family.

Dairy
Cawthron was fortunate to be in the right place at the right time to take advantage of changes in the structure of the dairy industry.
The tightening of general standards, the advantages of large scale processing and more demanding overseas customers meant that quality control requirements on the many small factories scattered throughout the country were making them uneconomic. Most factories employed just a few staff and the manager was often the one who did the simple lab work. This mainly involved measuring the fat content of the incoming milk so the supplier could be paid appropriately for his butterfat. Fat was easy to measure but was mainly relevant to butter production rather than cheese. New standards imposed microbiological limits, tests for the presence of antibiotics given to cows for mastitis and measurements of non-fat ingredients. Cawthron offered a service to these factories whereby an insulated box full of empty sample bottles was supplied so the next morning's milk could be sampled supplier by supplier. It was then sent for testing to Cawthron either by Newman's bus or sometimes by air.
Another regular test was for water content. When the milker rinsed the machines at the completion of the day this water sometimes, by accident or design, got into the bulk milk. This meant bigger milk tankers were required at greater cost, so factories set a limit on water content. We measured it using a small machine that determined the freezing point of the milk. As the water content increased the freezing point got closer to 0 degree C. After we started doing this a large company retired one of its milk tankers as it was no longer needed.
Mastitis infection led to a cow being given antibiotics and the supplier was not supposed to allow this milk to go to the factory as too high an antibiotic level could kill the culture that was making the cheese. If cheese would not form it was called a dead vat which might have to be disposed of. Just pouring it in into the nearest river was becoming more unacceptable.
We monitored all suppliers' milk for the presence of inhibitory substances, which were assumed to be antibiotics. If farmers had mastitis in a cow they would usually treat it with an antibiotic but having done so they were supposed to retain this milk and keep it separate from the rest. Apart from dead vats, the underlying concern was that people

drinking milk would be exposed to low levels of antibiotic which could make them resistant and compromise any future antibiotic treatment they were given. This remains a serious issue today.

As you could imagine, this work involved hundreds of samples a week. To do the test a small disc of filter paper was dipped into the milk and placed on a thin layer of agar gel in a petri dish. This gel had previously had a culture of Bacillus subtilis - a harmless micro-organism - incorporated into it. When it was incubated overnight a race took place. The antibiotic, if present, diffused outwards away from the paper killing the growing B subtilis so that in the morning there was a white film over the dish but a circle of clear gel free of the subtilis appeared round the paper disc. Any excessive clearance round the paper disc meant antibiotic and a failed test. This was bad news for a supplier and his day's milk.

Another dairy test we did was total microbial counts. These were a general indication of total numbers of bacteria present which would grow at 35 degree C and indicated general hygiene standards and how old the milk was. Sometimes they were used selectively to help solve particular problems.

At this time many suppliers did not have refrigerated holding tanks and it was not uncommon for their milk to be picked up every second day. In such conditions, bacterial numbers could multiply quickly. Milk arriving at a factory sometimes had counts as high as 100,000 per millilitre or even more, which would make a modern day food microbiologist shudder. This certainly made cheese production more difficult. Once we started doing these tests it was clear that certain suppliers had problems and improvements were undertaken. I always had sympathy for factory managers who had to explain the new tests to these suppliers.

Soil testing

This had been a Cawthron specialty from the earliest days of the institute and a technician, John Dodson, had been trained by Dr Elsa Kidson who was well regarded both nationally and internationally in soil science circles. Because of this the institute had both the background and experienced staff to analyse soils. The work we did for the NZ Turf Culture Institute was mainly to do with determining the fertility status of the soil as a guide for greenkeepers when they came to apply fertiliser. We tested for calcium magnesium, sodium, nitrogen, phosphorus, cation exchange capacity, base saturation and pH.

Soil samples were air dried and sieved to 2mm before being tested using a variety of analytical techniques. Nitrogen was done by the Kjeldahl process, phosphorus by molybdenum blue and calcium, magnesium and sodium by atomic absorption spectrometry (AA).

Wood chips

These were tested for moisture content, particle size and sometimes bulk density. The work was done by John Dodson and a team of casual workers. These were called chippies and were frequently retired men. They sampled the chips as they were loaded onto a boat via a sampling port built into the pneumatic loading system. A sample was taken every 15 minutes, 24 hours a day until the boat was full. This usually took three to four days and continued during the night and over the weekend, including several Christmas days. There was always pressure to get the results out as no money changed hands until we presented the report.

To measure the moisture we had a bank of six drying ovens running at 105 degree C. The particle size was done by passing the chips through a large nest of shaking sieves about 600mm square. It was good regular, profitable work.

Water lab

Much of the new research had an environmental theme and the quality of natural waters was a big part of this. It started with the impact humans were having on lakes Rotoiti and Rotoroa, Tasman Bay and local rivers.

To do this work a laboratory capable of a wide range of water and environmental analyses was necessary. Water is sometimes difficult to analyse as the concentrations are usually very low and everything tends to finish up in water eventually.

Dr Mike Taylor had set up this lab and oversaw its operations, which had about two to three people at the start. It included a postgraduate student who was working on the Te Waikoropupu Springs for her degree.

This was a time of increasing awareness and concern about environmental matters in general. Catchment boards and local councils throughout NZ were taking more interest in waste disposal and water quality so it was not surprising that we started doing a lot of testing work for these agencies. This lab was to grow and become a major part of the institute's services.

While Barry Cousins died just a month before the new labs were officially opened, the changes he had initiated would have a lasting impact and were instrumental in Cawthron's survival. The new work was starting to generate much-needed income for the institute.

Barry's role in turning the institute around deserves greater acknowledgement and Cawthron was fortunate his excellent replacement as director, Royd Thornton, built on the foundations he had laid.

A new director

In 1962 there was a call for fresh ideas in the science fraternity. Royd Thornton, who was an executive officer at the DSIR, responded by writing a proposal for the establishment of a biotechnology/microbiology group within DSIR. Royd's boss - assistant director general Ian Baumgart - was in favour of the proposal but the director general William Hamilton was not and it was not adopted. However, when Barry Cousins was looking for a way to reshape Cawthron in the mid 1960s he spoke with Royd and decided to take up his idea. When Barry died it was no surprise that Royd was encouraged to take up the vacant position. I do not know if the position was advertised or if there were other applicants, but Royd got the job. At first he had other commitments at DSIR so started part time, shuttling back and forth between Wellington and Nelson. He did not become full time until late in 1971.

Royd came with several important assets. He had an understanding and experience of government systems, policies and procedures and he had many personal contacts in the NZ science world that would be invaluable in the years to come. He also allowed us to be part of the DSIR family both directly and indirectly.

We sat in an unusual but beneficial position in the scientific community. On the one hand, we were commercial and independent and theoretically able to do what we liked. Industry and clients could feel that we were one of them and could fight for them against bureaucracy and the Government if need be. We tried to act in a totally business-like way. On the other hand, we received a significant government grant and staff could join the state pension scheme through the National Provident Fund and also the PSIS. The director attended meetings of the research associations and generally kept in close contact with government officials. This may have appeared to introduce the possibility of conflicts of interest but at the end of the day our independence was the key factor.

Life in the labs

The initial structure set up by Barry Cousins was built on five main laboratories or groups of workers. It comprised soil-wood chips-dairy, microbiology, water and waste water, trace elements (although this did not have a fixed home) and food-pesticides-organics. Most projects were done either in one of these labs or shared, although occasionally a small team was assembled to do a specialist job, such as hop testing or testing apples for calcium. As well as this there were stand-alone groups formed to do automotive engine testing, wood burner testing and environmental and feasibility work. Each of these had their own premises.

Soil, wood chips and dairy lab

By the early 1970s our soil testing work had virtually ground to a halt with the Turf Culture contract only running a few more years. Wood chip work, on the other hand, continued into the 1990s and generated a substantial financial return. Dairy work first expanded and then slowly disappeared as companies merged and got their own laboratories.

Dairy

At one stage in the mid 1970s, we were servicing dairy factories as far away as Timaru, the West Coast and Wairarapa. But work dried up as amalgamations produced fewer and bigger factories with their own labs. Cawthron was only called in to do specialist work. For example, milking machinery used to be cleaned with a type of cleaner called Iodophors. These contained mainly iodine as a disinfectant and phosphoric acid to control milk stone, a mineral build-up due to the calcium in the milk. It was a good product but it was often left in the machines overnight and sometimes it finished up in the next day's milk sent to the factory. In some ways this was good as low iodine has historically been a problem in the Kiwi diet but cleaning materials should not really be present in milk. To determine if or how bad the problem was, we measured iodine in many milk samples. Milk from cows grazing near the coast seemed naturally to have higher iodine levels but there were samples that were very high. Because of the very low levels of cleaning material involved testing was difficult and I did all this work. Other specialist dairy work mostly involved more complex microbiology.
Soon after arriving in Nelson my wife Marylyn started doing phage testing for factories. It was a time when the old Hansen cheese culture starters were still in use and these were more prone to phage problems, whereby a virus killed the culture and so the cheese was not formed.

Wood chips

This work was lucrative and long lasting for the institute. John Dodson and his team did a sterling job day and night all year-round to keep this going regardless of the weather. At one stage we were testing chips from Nelson, Auckland, Port Chalmers in Dunedin and Tauranga.

Soil

Once the Turf Culture contract finished the only soil work we did was for local people. They would bring soil in to be tested and get advice as to why their vegetables would not grow. Consumers Institute did provide work for six months or so in the late 1970s whereby they sent us soil samples from the gardens of subscribers and we gave results and recommendations. These recommendations were based on an analysis system provided by Lincoln College's soil department. We entered the results in a spread sheet macro that I set up and the recommended fertiliser application appeared. It provided some work but never really took off.

The microbiology lab

When we arrived this lab had just been established at the end of the present food wing under Gwen Robinson. She had recently graduated and was doing dairy and water testing. Marylyn had been mainly recruited as a research scientist and as part of this spent some years working on the incidence of antibiotic resistance in coliforms from the Boulder Bank sewage discharge and whether this showed up in environmental organisms. In 2015 this question has again become of interest. The implications for the shellfish industry and public health in general are important. As well, Marylyn oversaw the microbiology lab services and helped with the more complex problems. In some ways the difficult service work was of the most interest to her. Cawthron's lab stood out nationally as it was the only one in the country at the time willing to tackle difficult environmental microbiology. Most NZ labs were pathology labs and concentrated on human microbes, which live at 37 degree C, the temperature of blood. However, we looked at organisms that grew at temperatures ranging from below freezing point to over boiling point. The reasons for the testing included food quality and control, shelf life of foods, water quality, effectiveness of disinfectants and preservatives, public health generally, quality control of pharmaceuticals and biodegradation due to attack by microbes.

Antibiotics

While we tested milk for antibiotic contamination, we also assayed antibiotics when they were used in veterinary products. This was much more sophisticated and used identical stainless steel cylinders that held an exact volume of diluted sample rather than filter paper discs. This enabled the clear zones to be measured to 0.1mm with engineering callipers. This was replicated many times and measured against the standard before a statistical analysis of all the results yielded an answer. Erythromycin was one of the troublesome antibiotics as the raw material imported from overseas was under strength, according to us. We went to great lengths to verify we were right, including importing standards from the Lister Institute, an offshoot of Marylyn's old employer.

Testing formulations was not usually too much of a problem if there was only one antibiotic present but it became tricky when products contained several different antibiotics and the client wanted individual analyses. As all antibiotics are inhibitory to microbes, they all showed up as a combined total strength rather than individual results. There were a number of ways round this but one answer involved Marylyn breeding an organism that was resistant to one or more of the antibiotics present so that under specific testing conditions they did not show up. A lot of tests and simultaneous equations were used in the final mathematical calculations. A school teacher at Nelson College was asked to develop the maths for linear regression and write the computer program in Basic. This was progressive stuff given it was the mid 1970s and computers were not widely used. We were probably the only lab In NZ which could do this and it gave us long term work.

Biodegradation projects

It is surprising the range of materials that micro-organisms will attack. They will eat anything under the right conditions and we worked on several problems.

Thiobacillus concretevorous

This bug with a great name eats concrete under the right conditions and when sulphur containing gas is present. This organism will eat concrete at a surprising speed. The sulphur in the gas oxidises to make sulphuric acid which eats away at the concrete. This commonly happens in sewer pipes and in cooling towers in geothermal power stations, although can occur anywhere where there is a combination of sulphur containing gases, concrete and warm temperatures. We worked on both sewer pipes and geothermal cooling towers. Our role was to identify the presence of the organism and help select the right biocide to add to the water to slow up the problem bug.

Engineers took a simpler route and just made the concrete thick enough to allow for some loss. For Nelson sewer pipes the temperature wasn't quite warm enough to be a major problem like it is in tropical cities, although there was some attack at the time. Furthermore, we now have mostly polythene sewer pipes which eliminate the problem. Some warmer cities have resorted to fibre glassing the inside of pipes to stop attacks.

Hop strings

An interesting but inconclusive study was done on hop strings. These used to be made of hemp and rotted down when composted in the hop debris. When the strings changed to polypropylene we tried to develop a microbe that would break them down in compost and had some success. Micrographs of the strings with big lumps taken out of them showed they were degrading but ultimately the practical difficulties were too great.

Binder twine

Hay bales use binder twine to hold them together but when they sat on the field for too long the twine degraded and snapped, and hay was lost. We tested four different twines on the market for resistance to the sort of organisms that might be encountered in the field. Three of these were very poor, breaking down easily, while one was very good. This evidence allowed farmers to make the right choice when buying twine.

O rings for sewer pipes

One day a Nelson City Council engineer brought us some O-rings taken from sewer pipes that were in an advanced state of breakdown. They were natural rubber and a microbe had been eating them. It was a small project but we helped identify the problem organism and after testing advised on an alternative choice of O-ring material which the microbe didn't eat.

Osmophils in frozen orange concentrate

ENZA came to us with problems with their USA-sourced frozen orange juice concentrate that was used for apple and orange drinks. Not many organisms will survive and grow in concentrated fruit juice as the combination of acidity and high sugar levels usually kills most things, but some do survive. We found the problem was not so much with the concentrate but once it was diluted which allowed the organism to grow rapidly. The drums of concentrate varied widely so we had to test each one. A stainless steel corer was made to sample the middle of a 200 litre drum and tests made on each. Some were okay and others were not but the client had been reassured that they could identify good material.

Wine industry work
Apart from routine testing, two lines of work stand out. Botrytis was and is a problem with grapes and we checked crops for worried winegrowers. We also assisted in controlling the microbiology of the malolactic or secondary fermentation of wine. This was encouraged to reduce the acidity but was often hard to start.

Listeria
This is a difficult organism to control industrially as it will grow at low temperatures. It is quite happy growing in the fridge, and can be a serious health threat for the very young or old. In the 1980s a mother was advised to eat green lipped mussels while she was pregnant with twins and as a consequence both babies died of a listeria infection. Previously there was no way the source of the infection could be positively identified or any company or person held responsible, but when this tragedy occurred DNA typing was well established. After much testing, it was shown that the particular listeria strain that killed the twins was unique to the mussel processing factory at Rai Valley. The question therefore arose, did the management of the factory know that they had listeria in their product and, if so, should they face murder or less serious charges. The case obviously had serious implications for the food industry.
When the police started their investigation they soon realised Cawthron had been testing this company's products for some time and that our documents and results were required as evidence. One morning – just like in the movies - several police cars arrived at speed at Cawthron and officers seized all the records, books and documents relating to microbiology testing. Once the dust settled we persuaded them to just take the records relating to the long term monitoring of the Rai Valley shellfish company so we could get back to work.
The case had a high profile which attracted overseas media and much public interest. At one stage there was talk of a film being made about it. While some staff at the factory were convicted, the murder charges did not get very far.
One spin-off for us was that mussel processors became very quality conscious and we started to get lots more listeria work. I remember one Christchurch salmon producer who was having terrible trouble getting his processing equipment free of the organism. No amount of disinfectants and scrubbing seemed to be killing the bug. The eventual answer was to seal the whole processing area and install lots of heaters. The whole room was brought up to 45 to 50 degree C overnight and this did the trick.

Disinfectant testing
Changing regulations meant manufacturers had to prove their disinfectant formulation actually killed micro-organisms. While the manufacturers used well established active biocides, they did not always work. Sometimes there was a reaction between a combination of ingredients that led to reduced or eliminated disinfectant activity. Formulations containing chlorine were often a problem as it reacts with lots of things to become inactive. If products failed it usually led to us helping the company develop something that did work and this involved ongoing testing.
Our tests were a dilution type test where standard cultures such as E coli, Staphylococcus and Pseudomonas aeruginosa were exposed to the product at the recommended concentration and either side of the recommended concentration to see if the cultures died. I remember one very well-known product that positively encouraged one of these organisms to thrive, which was far from a desirable result.
One interesting project was testing nappy sanitisers for the Consumer's Institute. Samples of nappies were coated with a small volume of a culture made from the faeces

of three to six-month-old babies - which proved more difficult to source than we expected - and then put through the rinse according to the manufacturer's instructions. The samples were then tested to see if any bacteria had survived. If I remember correctly only one product worked and is still on the market and popular today.

Extremophiles
Most micro-organisms live at warm temperatures and most of the ones that cause humans trouble live at or near 37 degree C, the temperature of our blood. Pathology labs and hospitals know all about this type of organism but once you start getting significantly warmer or cooler than 37 degree C there is far less medical interest. Cawthron filled that gap, becoming an expert at what lived at temperatures ranging from 10 to 40 degree C and sometimes far wider than this. A lot of the work related to storage conditions for food. The other main NZ lab doing this type of work was the National Institute of Health and we worked closely with it.

Takapau water supply
By the end of the 1980s Cawthron had developed a reputation throughout New Zealand and was literally doing work from North Cape to Stewart Island. Part of this was due to Marylyn Cooke who had had become one of the country's leading authorities in environmental, including food, microbiology. If you had a difficult problem with a strange microbe Marylyn was the person to go to. It even developed into a slight management problem as clients tended to head straight to her rather than going through the system.
One problem related to the water supply at Takapau freezing works in central Hawke's Bay. The water had coliforms in it despite frequent and heavy chlorination of the whole system. It took several trips to the meat plant and further testing before the problem organism was found hiding in the corner of a large sand filter where the chlorine did not penetrate.

Xanthan gum
This was a joint project between a research department scientist, Andy Broderic, myself and Marylyn that started with a lot of promise but did not quite make it.
Whey was traditionally fed to pigs but around this time there must have been too much pork on the market and whey was a problem waste. Whey contains the milk sugar lactose and we isolated a particular strain of Xanthomonas (usually a disease of plants) that would grow on lactose and produce Xanthan gum. This is a valuable gum widely used in the food industry as a thickening agent. It has unique properties that other food gums do not have. We thought we could be onto a winner. If it was to be a commercial proposition, production needed to be on a large scale. Coincidentally a very large plant in New Plymouth became available. This factory had been built to process and extract the native poroporo plant to obtain steroidal ingredients that could be used in the manufacture of the contraceptive pill. Up until this stage the Mexican yam had been used as a starting point for the contraceptive, but the instigators of the poroporo project were hopeful of creating a new industry in New Zealand. Unfortunately, unbeknown to this company, the Chinese had beaten them to it, having obtained the poroporo plant and started to grow and process it. It spelt the end of the NZ venture but it meant there was a nice new factory in New Plymouth available for hire.
After finding a large local industrialist as a commercial partner we set up a small lab there and started experiments. After a highly promising six months we were confident we could produce a reasonably pure product for the marketplace. Soon after this we

became aware that a similar product had just been launched at a very low purity but very cheap price. We had been too slow and missed our opportunity. We decided to back out, although it did seem just the sort of industry that NZ needed.

Wallpaper

Wallpaper has the potential to go mouldy and to prevent this biocides are usually incorporated into it to stop growth. Some of the better biocides were becoming unacceptable because they contained chemicals such as PCP (pentachlorophenol), while others weren't working. We did quite a lot of work helping manufacturers with this problem.

Phaffia rhodozyma

This is an interesting bright red yeast. Around the mid 1980s the salmon industry was buying Australian astaxanthan pigment to help colour farmed salmon. This pigment occurs naturally in marine algae, flamingos, krill, shrimps and crayfish along with the yeast. I suspect that all marine organisms owe their colour to the algae at the start of the food chain. We were working on behalf of a salmon company and produced a small quantity of powder but they did not proceed. It is interesting that there is now a Nelson company, Supreme Biotech, using Cawthron technology to grow the algae in plastic tubes on land to produce astaxanthan. Back then we thought that growing yeast was not too difficult as bread and wine makers do it all the time, and that we might be able to produce a much cheaper product. We did grow the yeast and it did seem to colour salmon but the project never progressed. A lab In South America started producing the yeast as salmon feed and I think they are still going, which suggests we may have missed an opportunity.

Manuka oil

In the late 1980s I received a phone call from Sid Clarke who lived in the East Cape community of Te Araroa. He represented a Maori trust which was looking into the commercial use of its substantial manuka reserves. These contained a lot of large old trees and the wood was regarded as a resource that could be harvested, milled and used for furniture and maybe parquet flooring. Unfortunately, the large amount of foliage that would be generated was a problem. I suggested that essential oils could often be extracted from foliage and had they thought of doing this. They had, but a sample of oil prepared and tested at the Gisborne Hospital lab had shown no useful activity. While not wanting to cast any doubt on the hospital, I pointed out to Mr Clarke that measuring antimicrobial activity was a specialist job and that we had quite a lot of experience with this type of work. I offered to do a little work at no cost just to see if we thought there were any possible benefits. It sounded like a fun project and you can never tell where it might lead you. A few weeks later a large sack of manuka leaf arrived and I set up a small steam distillation unit to extract the oil. I only obtained 20 or 30ml but it was enough to have a quick look. I took it up to our microbiologist Marylyn to test.
Bacteria live almost exclusively in water and oil and water do not mix. This was the fundamental problem we had to overcome before any testing could be done as microbiology is done in water. Research suggested an emulsifier and a product called Tween or Polysorbate 80 should be used in testing. It was tried and found to work very well so some small trials were undertaken.
The manuka oil was subjected to a MIC test. This stands for minimum inhibitory concentration and measures the lowest concentration of the material that would stop a particular microbe from growing. The sample and a culture of the particular organism in

a growth medium are incubated together. If there is no grow of the organism, then the sample at that strength is inhibiting growth. The sample was diluted by halving its strength at each step until eventually it was too weak to stop the organism growing. With some materials, a concentration of 5 or 10 per cent might be needed to prevent bacterial growth, whereas chemicals used as preservatives in foods often work at about 0.1 to 0.2 per cent. It therefore came as a huge surprise and created great interest in the lab when our tests showed staphylococcus aureus was killed by manuka oil at less than 0.05 per cent. Manuka also worked well against other organisms tested.

After telling our clients that money was needed to do some serious work, we obtained a substantial Maori Business Technology development grant to conduct a thorough investigation. One of the conditions of the grant was that the DSIR had to be involved so they shared the application. The initial work took several months to complete, with the whole project spanning several years. A report was issued in 1994. It tested about 40 organisms against four oils - East Cape manuka, East Cape kanuka, Australian melaleuca (tea tree oil) and high terpineol pine oil (as used in Dettol). The reason for including these other oils was to clearly establish the relationship between them under the same testing conditions and to see which was more active. Later on we also tested different manuka oils from throughout the country when it became clear that not all oils are created equal. It did throw confusion into the whole identification question between manuka and kanuka which took botanists a few years to sort out.

The report was well received and on the basis of this a company, Tairawhiti Pharmaceuticals, was formed and a steam distillation plant built. Oil was recovered and a company operates to this day producing several hundred litres per year. One of the main uses for the oil is in air conditioning systems in the USA to control legionella.

This work was not officially made public, although a report was produced that is now internationally known as the Cooke and Cooke report. I did not find this out until early 2000 when I received a phone call from an international document centre based in the USA which told me about its popularity. After discussions with the client it was decided that distributing the report might boost sales. We sold hundreds of copies at $25 each and the institute still gets inquiries, although I understand Cawthron has stopped producing them.

After we got the ball rolling DSIR did a lot of work trying to find out what the active chemicals in the oil were and assisted Tairawhiti Pharmaceuticals with production. As an aside, the active ingredients in manuka oil are known as a class of chemicals called triketones. These chemicals had been synthetically produced in a German university chemistry lab and identified as probably having strong antimicrobial activity. They claimed the chemicals had never been identified in nature but manuka testing proved otherwise.

Fire in the lab

One morning during the early 1990s the storeman delivered a 2.5 litre bottle of 95 per cent alcohol to the microbiology lab, which was then upstairs at the end of the north west wing. It had been a frosty night, the alcohol was cold and unfortunately the bottle had been filled to the top with the cap firmly screwed on. It was left on the bench while everyone went for morning tea. Over the next 10 minutes or so the alcohol warmed to room temperature, expanded and in the absence of any headspace, cracked the bottle, spreading the flammable liquid over the benches and floor. Microbiology labs always had a Bunsen burner running in those days for sterilising the wires used to streak plates so that when the bottle broke there was a naked flame nearby. Soon the whole lab was well alight.

The first person back from tea discovered the fire and set off the alarm. This was connected to the local fire station and a fire engine was soon dispatched but in the meantime Ray Wills and I rolled out a fire hose in a bid to douse the flames ourselves. Fortunately, the fire was still confined to the lab and we were able to poke the hose between the swing doors without going in ourselves. It was a big hose and delivered lots of water so we soon had the fire out just as the brigade arrived to take over. The fire didn't cause too much damage and hadn't penetrated too far into the lab's wooden benches.

Tim's vinegar culture

In the early 1970s Frank Archer was chairman of the Cawthron Trust Board and his daughter Wanda Taite ran Redwood Cellars after her husband had died racing cars on the Tahunanui back beach. Tim Coulter was chief winemaker for Wanda and soon after my arrival in Nelson Frank introduced me to them. One of Redwood's main products was cider vinegar. While theoretically a simple process, the practicalities of making it can be challenging. Apple cider wine is first made and then put into the vinegar plant where large volumes of air are introduced along with the acetobacta vinegar culture. This culture then oxidises the alcohol in the cider to produce acetic acid and a lot of heat.

The bacteria used are very fussy as they like it warm but not too hot otherwise they die. They also require a constant and plentiful supply of air or they perish in a few seconds, and they need just the right food mix. If the tank dies it is a real pain getting it going again. Sometimes it just refuses to start. I have known tanks to sulk for a week before getting going. One of the problems that can arise is when the person who made the cider adds a little sulphur dioxide. This is normal practice when making cider because residues of sulphur dioxide can stop the vinegar bacteria from growing and for cider this is good. For vinegar, of course, it is not what is required. There is definitely an art to the whole process.

A good clean and pure starting culture is very important as a mixture of organisms can develop in recycled house cultures. Marylyn spent some time isolating and purifying a culture of acetobacta to make the whole process more reliable.

Over the years I became quite knowledgeable about vinegars and wrote a book in conjunction with two others that was never published, although there is a possibility it might happen this year. I also took out a patent on the use of vinegar for the purification of drinking waters for humans and stock but commercialisation was too big a project for us and we let the patent lapse.

Bromley ponds

These oxidation ponds are part of the Christchurch sewerage treatment system. They attract a lot of ducks whose excrement invariably ends up in the ponds. We were asked what portion of the pond loading was due to the people of Christchurch and what portion was due to the ducks. We decided that human waste would have bacteria with a high percentage carrying antibiotic resistance due to many people taking the drugs. On the other hand, ducks did not normally have much exposure to antibiotics, and testing of their droppings and fresh inlet material to the pond confirmed this. A number of measurements throughout the ponds gave an antibiotic resistance level that allowed us to calculate the percentage of duck poo, which showed they did not contribute much. It later emerged that the main reason we were asked to do this research was to see if or how much faecal pollution the ducks were transferring to the Avon-Heathcote estuary as they flew back and forth. There was some but it was unclear if it was from the ducks or from pond discharge.

Shellfish sanitation

In the early 1970s we had a meeting with some visiting Americans who had been doing some research on the growing of green lipped mussels which were common in South America but also present in NZ. They suggested starting an industry in NZ based on them. Over the following months several possible growers in the region were approached but they showed little enthusiasm. The Americans left and we forgot about it until a few years later when the idea resurfaced and this time it did take off.

We did regular monitoring work for the industry as well as research into the association between water quality, nutrients and mussel growth. As the market expanded, the problem of high microbiological numbers in shellfish came to the attention of the Health Department and we obtained a contract to investigate this. We did the sampling and testing to set the criteria for harvesting. In simple terms, the Pelorus River would get rain in its catchment and discharge high microbial numbers into the sea. These were taken up by the shellfish, making them unsafe to eat. It would take some days for the bacteria to clear. We correlated the river flow, rainfall, position in the sounds and microbial quality of the shellfish. Our sampling and testing went on for at least a year. There is now a system where shellfish cannot be harvested within a certain time after rain. This industry continues to be important to Cawthron.

Mites

The local apple industry had problems with mites and there was a drive to reduce the use of pesticides which was used to control them. As an aid, a predatory mite was introduced to control populations of the problem mite. To monitor how the scheme was going, farmers sent us leaf samples at regular intervals for testing. The leaves, about 50 a time, were put through a special commercial brushing device and the removed mites identified and counted. If the ratio of pest mites over predatory mites got too high, it indicated the farmers needed to apply a pesticide. This provided us with regular seasonal work and ran for some years.

Diesel oil

One day a fisherman came to see us with a problem. He had been well out to sea in a reasonably large fishing boat when he started having trouble with fuel flow to the engine. The fuel filter seemed blocked and he had difficulty getting back to port. When the engine was stripped down the filter was found to be caked in a stringy mat of fibrous material. He brought us this mat, which was of microbial origin and was obviously growing in the fuel. If petroleum products get wet - which is sometimes due to condensation in the storage tanks - the added water can support microbial growth. The organisms live in the water but eat the petroleum or in this case diesel. The fisherman had suffered financial loss and wanted compensation from the oil company which supplied the fuel.

NZ flax

A client approached us wanting to re-establish flax growing in NZ using native varieties. However, there was not a lot of it about so tissue culture was suggested. While this was a specialist field, it basically involves microbiology techniques. NZ flax had supposedly been used for bank notes because it produced particularly strong paper. We obtained flax plants from Foxton where the client lived and where flax growing used to be a major industry. We planted some in the garden island that was originally outside the front door of the institute so that samples were readily available. Some also finished up in staff gardens. We were more or less successful in developing the technology required to produce flax seedlings but the client did not proceed. I still remember the morning search for very green bananas in town to use in the growth medium for the tissue culture. When we finished the project we had some small bales of semi-processed flax which we sold to local craft people for weaving.

Water and wastewater lab

This was the largest and arguably most important lab on the commercial side of the institute both because a lot of the institute research related to water and because of a growing community concern about water quality. Some was done for Cawthron itself, but most was for regulatory authorities such as catchment boards and also farmers. It involved testing drinking water, stock water, industrial water and waste water. As time went by we found ourselves doing most of the testing for Nelson, West Coast and Christchurch and a lot of work for Dunedin and Auckland. The lab employed six or seven people, not counting the microbiologists. The bigger local authorities usually sent us the more complicated work such as pesticide residues or difficult discharge problems. Our reputation and independence was the key to getting this work.

Farm water

Farmers mostly came to Cawthron to get either their household water or stock drinking water tested. Well water quality was a common problem in particular parts of the Nelson region as this water sometimes had a high level of dissolved carbon dioxide that made the water acidic. If this water went straight into the household copper hot water cylinder the acidity started to eat away at the metal, which had two dramatic and costly effects. Firstly, if the farmer's family had light coloured or blond hair and washed it in this water their hair went green. Secondly, the cylinder often did not last long. The record that I remember for a new cylinder was three months before it disintegrated. This problem was fairly easily fixed by a simple process to remove the carbon dioxide usually by spraying into a water storage tank to allow the acidic gas to escape. Sometimes coarse limestone was added to help the water treatment. We included a photocopied handout of what to do in our reports.
Another more uncommon problem for farmers was when toxic blue green algae grew in stock watering troughs. This could cause sickness or death. The vinegar patent previously mentioned was one effective remedy.

City water

Drinking water for larger communities has to be tested very regularly and is done daily in big cities. Testing for Nelson City Council and other local authorities provided Cawthron with a steady income I could budget on. Water seepage from one property onto another was a regular problem, particularly when it might involve a broken sewer pipe. It was usually checked microbiologically by testing for faecal coliforms and even faecal streptococci. The presence and ratio between these two told you if it was likely to be faecal in origin and whether it was human or animal.

Waste water

Analytically this can be complicated as almost anything can finish up in waste water. For regulatory purposes, specific contaminants are looked for, including poisonous ingredients like lead, cyanide and sulphides. Also, more general indicator tests are

conducted to show how the waste water might behave once it gets into the environment. Apart from things that may be poisonous or dangerous, the general test includes measuring pH (acidity or alkalinity) COD (chemical oxygen demand) and BOD (biochemical oxygen demand). With experience much can be gleaned from these three results. For lab workers this testing was not really dangerous, although there was the odd exception. Late one afternoon samples of effluent from a piggery were received and accidentally left on the bench overnight, which was not normal procedure. This particular sample was very strong and when the lid was removed in the morning it virtually exploded, spraying fermenting pig manure all over the ceiling and many of the benches. The smell was overpowering and the stain on the ceiling lasted for many years and was still there the last time I was in the lab.
We monitored trade waste discharges to ensure that various industries were operating within their discharge permit and were meeting city bylaws. There were occasional dangerous discharges where urgent action was needed and this required us to work closely with the local body.

Hazardous Substances Technical Liaison Committee
My involvement with chemicals in the environment went a little further as I was put on the regional Hazardous Substances Technical Liaison Committee. These committees were formed after an incident involving dangerous chemicals on a wharf in Auckland some months earlier. It had alerted fire brigades to the fact that they were the first response team when there was a dangerous chemical spill, dangerous materials in a fire or other problems with hazardous materials. The brigades felt ill equipped and inexperienced to deal with these potential situations and set up the committees as advisors. They included police, ambulance service and fire brigade representatives and an industrial chemist with some knowledge of dangerous chemicals. We met monthly and undertook simple training with breathing gear and watched training videos based on overseas incidents. Thankfully I didn’t have to don full breathing gear and run up and down stairs, but I did get a few rides in a fire engine. Occasionally we were called to Picton after things leaked or spilled in a bad ferry crossing, but mostly it was local spills usually involving acids or agricultural chemicals.

Eves Valley effluent
In the early 1980s Australian conglomerate CSR investigated the feasibility of establishing a forestry processing complex including a sawmill, a thermo mechanical pulp plant and a paper mill at Eves Valley near Brightwater. Water would probably have come from the Motueka River and the effluent disposed onto land. There were a lot of issues but I was asked to look at whether getting rid of effluent this way was feasible and safe. Using a large bulldozer, I arranged to take about 20 cores of earth about 1m long and about 150mm wide which were forced directly into plastic sleeves. This produced a soil core in its original state and structure. These were mounted in the old tomato glasshouse at the back of the institute. An identical effluent was brought down from the Whirinaki thermo mechanical mill near Napier and applied at the proposed rate. Measurements were taken before and after the effluent passed through the soil columns. As expected, the effluent was virtually 100% purified by the soil. As local people will know, CSR pulled out of the project, with just a sawmill being built on the site. As well as the effluent work, a full environmental impact report was prepared.

Ammonia urea plant
The Eves Valley experience led us to being invited to help with water and waste issues with the new Think Big projects in Taranaki. We worked on the ammonia urea plant, the gas to gasoline plant and the stand-alone methanol plant. Most of my work involved the land disposal of waste water which contained both ammonia and urea. Concentrations were low but there was a lot of it. We had to work out how much nitrogen a Taranaki field could safely take. Once again it required soil cores and trials.
After the initial planning stages there was ongoing contact with these projects mainly monitoring waste water for many years to confirm they were operating within their water rights. We also lost our chief chemist from the water lab, David Haden, who ended up working at the gas to gasoline plant. It did have a funny side. Just before David went up to his job interview he asked me what sort of questions he might expect and I suggested two that I would ask if I was in the same position. They were a little obscure but I thought relevant. He got asked both, knew the answers and got the job.

Telarc
An important part of the water lab and indeed all the labs was membership of TELARC (Testing Laboratory Registration Council). This had been set up with the help of our Australian neighbours who called their system NATA. It was designed to ensure that a lab or testing organisation puts out reliable results which are consistent with those produced internationally. Labs were inspected every three years and annually if they were not going very well. We were certified, inspected and asked to do common samples called round robbins. The system is frequently used. Last year (2014) the Christchurch City Council had its TELAC registration withdrawn for building permits. This signifies a major problem and is only done as a last resort.

Trace elements lab
Most of the time trace elements were of interest because they were poisonous. The so-called “heavy” metals lead, mercury and cadmium always got our attention because they usually should not be there. The next important group was the wood treatment chemicals of arsenic, copper and chromium which were still poisonous but not quite as bad as the heavies.

Mercury
Late one afternoon we got a telephone call from local fishing company boss Michael Talley informing us that a shipment of their fish had been rejected in Australia because of excessive mercury content and could we test further shipments before they were sent, without delay. At the time we had an atomic absorption spectrophotometer which is usually used for trace elements but the levels were too low to detect them accurately using it as it was. Instead, in good Kiwi tradition we decided to build our own vapour unit to increase the sensitivity. Silica windows were cut from old lamps used in an even older emission spectrometer and a flow cell was made using Araldite and lab tubing. The fish samples were digested in acid and the resulting clear liquid was reduced to produce elemental, volatile, mercury in a tube that had nitrogen gas bubbling through it. As the plug of vapour passed through our new cell in the atomic absorption spectrophotometer, a chart recorder measured the signal that represented the amount of mercury present. The Talleys had the results by midnight, which enabled the fish to be dispatched in the morning. This vapour unit lasted many years until more modern equipment was purchased. Mercury testing was done on all containers of fish leaving

the country and we did most of it. It was a very good money spinner, earning up to $100,000 some years.

Timber treatment
Tanalised wood was becoming popular and treatment levels had to be checked when it was used in applications such as house foundations and wharf piles. This involved taking a small core from the pole and analysing it for copper, chromium and arsenic. A minimum content at depth had to be achieved in the treatment. For expensive poles we in effect certified them. An interesting problem arose in the 1970s when the NZ Electricity Department was putting power pylons through Nelson Lakes National Park. Building the big towers was a major task and a village for workers was set up while they did it. Tanalised wood was used in the construction and the leftovers burnt on the camp site. Unfortunately the ash was eaten by the local farmer's cattle that grazed the surrounds. They probably found the arsenic in it quite sweet to taste. Unfortunately, most of them died which didn't amuse the farmer and I think led to a court case.

Pottery
Glazed imported pottery was routinely checked for soluble lead and for other toxic elements such as cadmium (This was used in red and orange glazes.) The method involved soaking the pottery overnight in diluted acid and AA (Atomic Absorption Spectrophotometry) analysis of the liquid in the morning. This work was done for NZ Customs.

Engine wear
Transport Nelson gave us a short term project on metal wear. As an engine wears very fine particles of metal finish up in the engine oil. It is expensive to take a large truck off the road for servicing so a quick metal test of the lubricating oil can tell you if any part is starting to break down. The different parts of the engine are made up of different alloys so that an analysis can give a good indication of which particular part of the engine needs attention. By doing this the engine only needs be serviced when required. We monitored several trucks for several months, but I don't think the economics were favourable. However, I understand diesel electric railway engines did use the system.

Food, pesticides and organics lab

Insect hormone
We were always on the lookout for ways to make money. The biochemistry division of DSIR had isolated an insect moulting hormone from the bark of the native yellow-silver pine or Lepidothamnus intermedium. It occurred at about 1 per cent in the bark so each tree contained a lot of this chemical which had potential as a natural pesticide. I suspect it was part of the tree's defence against insect attack. We looked up the price of the chemical in the Sigma Catalogue and almost fell off our lab stools where it was listed at $10,000 a gram. That meant a single tree might contain 1000g worth $10 million. With visions of wealth, we obtained some bark and started extraction, eventually isolating a gram or two. We sent out 100mg samples to a few people and then realised that the world market per year was only a few mg. We had flooded it. Our enthusiasm had got the better of us, although it was good fun at the time. Interestingly, the present day retail price of $70,000 a gram suggests there may still be an opportunity.

Fishmeal

This is a versatile and valuable product for the fishing industry, selling at different prices depending on its protein content. Because of this it provided us with regular testing work. About two-thirds of a fish is waste and it is a good source of nitrogen and other nutrients. The meal was obtained by crushing all the frames, heads and other unwanted bits of fish and cooking it to kill any microbes. This was then pressed against a filter and the solids removed, dried and sold for animal feed as fishmeal. Like milk, the liquid filtered off was passed through a separator where the fish oil and the water phase were divided. Fish oil had its commercial uses but at the very least fuelled the boilers. The water phase contained a lot of dissolved solids which included protein and fragments of protein, and some minerals, in particular potassium. This water was usually concentrated by evaporation to produce a syrupy liquid called stick liquor, which was sometimes used in animal feeds and also sold as a fertiliser for home gardens.

At one point early in the 1970s a forerunner company to Sealord was exporting 44 gallon drums of stick liquor to Australia for fertiliser use. It was being stored in a rather hot warehouse in Sydney. Unfortunately, it was warm enough to foster bacterial growth and fermentation. Eventually the pressure became so great, the drums burst, spraying fermenting fish liquor all over the warehouse and making everything else stored there unusable. An answer was demanded and we got the job of stabilising the product which involved changing its pH and brix (concentration) levels.

We also undertook other projects for the fishing industry, including measuring the freshness of fish, microbiological testing and general problem solving in the factory. The freshness tests were interesting as they could pick up changes within less than an hour or so of the fish being caught.

Proximate analysis

When it became a requirement to have nutritional information on foodstuffs there was a big increase in the demand for these tests. Most packaged foods in the supermarket today will have a box with nutritional information printed on the side. This was called a proximate analysis and included testing for fat, protein, ash (mineral content) moisture and carbohydrate. Sometimes calories or energy were calculated from the other measurements and more recently other information has been included. Most foods today have this information on their labels and I believe there is an app that will give a more detailed breakdown by scanning the bar code.

Meat

Sausages are required to contain a certain level of meat as defined by the protein content and protein is usually measured as nitrogen by a lab. However, not all nitrogen necessarily comes from protein. Recently the Chinese got caught when some manufacturers started adding melamine, a high nitrogen chemical, to baby food to show an erroneously high protein level. It poisoned babies and caused a political firestorm. Similarly, when soy flour is added to sausages it shows up as protein and therefore meat. You just never knew what might be in your bangers. Fortunately, testing today is often more sophisticated so that this subterfuge is harder to get away with.

Food preservatives

Sorbate and benzoate are chemicals frequently present in foods and drinks and needed checking to ensure they were within the level required by food regulations. It was difficult for the manufacturer because the useful level was very close to the maximum allowed level. There were many others as well and a quick look at the NZ and Australian Food Regulations shows the range of ingredients we might be asked to analyse.

Beer
There are regulations on the alcoholic strength of beer and the Government monitors production to make sure that beers on sale conform and the correct duty is being paid. This was a routine job and Cawthron was lucky enough to get the contract. The test method was a modern one called head space analysis. A sample was warmed in a sealed vial and then a small quantity of the vapour was analysed using a machine called a gas chromatograph. It was rare to find a sample outside the regulations.

New pesticide registration
In some ways we were lucky that there was a surge in the number and type of new agricultural chemicals coming on the market during the 1970s and 1980s as there was an increasing requirement for testing residues.
Before a new pesticide was allowed to be sold and used in NZ the health authorities, such as the Agricultural Chemicals Board, had to be convinced that the product would perform the same way under our conditions as what the manufacturer claimed it did overseas. Extensive testing would already have been done overseas but NZ is a little different. This work mainly involved measuring how quickly the chemical disappeared when applied to the target crop, such as apples, pears, kiwifruit and berryfruit. The breakdown was usually caused by rainfall, temperature and sunlight so weather was an issue.
Trials were done for each new product on a local crop it was designed for and we measured the level of residue. Typically a high level was present straight after spraying and declined steadily as time passed. Newer products were very toxic but broke down very quickly, often being undetectable after three or four days. The old style products were less dangerous but lasted long term. A lot of the work was done for either Fruitgrowers Chemical Company or Ivory Spray Chemicals
When I started at Cawthron I did most of this type of work before Ray Wills took over later on, although I did keep a close eye on it at all times.
The difficulty with this type of analysis was that pesticide sprays were either not very even at times, there was very little pesticide applied in the first place or the pesticide chemicals were unstable and quickly broke down. To solve these problems we had to take big samples from throughout the tree or bush, work very quickly and use very sensitive test procedures. A case of apples may only have a speck of pesticide present and we had to find and measure it.
All the test procedures were basically similar. First was sampling to make sure that the material you tested was truly representative of the crop. This sometimes meant starting with a case of apples or more. The second part was to grind and mash the sample with a non-water soluble solvent that would dissolve the residues and then separating the solvent, maybe purify it further and concentrating it down to a few millilitres. Residue from a case of apples might finish up in half a teaspoonful of final solvent. The final part was to use a machine that separated the chemical you were looking for in a pure form and measuring how much was present. We typically measured down to 0.01 ppm, which is the equivalent of about a teaspoon in 500 tons.
As well as testing for residues we checked the quality of pesticide formulations often using analytical methods supplied by the manufacturer of the active material.
In one case we did not like the procedure supplied because we felt it was wrong and sent the German supplier our method which we thought was better. They insisted we

were wrong, but about two months later we received a revised analytical method which was exactly what we had sent them. We had a good laugh but said nothing more as the customer is always right.
Quite a lot of the residue work was to determine the loss of pesticides to the environment either for particular companies or for the regulatory authorities. We routinely monitored several waste outfalls that fed into waterways such as estuaries.
In the 1990s the use of PCP (pentachlorophenol) for timber treatment was being phased out. It was good at preventing the coloured sap stain on wood but was regarded as too environmentally hazardous. There were many small timber mills in the district which had sap stain dips. When either the mill or sap stain operation closed the level of site contamination needed to be assessed so a clean-up could be undertaken. This was straight forward and I did some of the sampling as it was a break from office and lab life.
PCP contains a lot of chlorine and was easy to measure by gas liquid chromatography using an electron capture detector. It could detect very low levels.
While not strictly pesticides, we also tested for several toxic organic materials. Polynuclear aromatic hydrocarbons were one of the main ones. These were often sent away to specialist labs for analysis.

Mapua clean-up

While at Cawthron I had a lot of contact with the Fruitgrowers Chemical Company at Mapua. We tested their pesticides and herbicides, helped with the registration of new products and checked their effluent to make sure it met the standards of their discharge permit with Tasman District Council. The company had been on its Mapua site for many years and predated most of the residential development. It was not a case of the factory coming to the village but the village coming to the factory. In the early days agricultural chemicals had lower toxicity but lasted almost for ever. More recently products became very toxic but only lasted days in the field.
When FCC closed in Mapua the future of the site became a vexing question as various groups had different ideas on what should be done with the land. There was no doubt it was heavily contaminated with pesticides but what to do about it became a hot political question.
I had my own views which involved sealing the site and putting a car park or supermarket on top, but the decision was made to try to decontaminate the soil at considerable cost and questionable success. I did not have access to all the test results from monitoring the estuary, but the ones I did see I did not think were too much of a problem. Sealing the top to stop leaching of rain into groundwater would have helped. But sometimes politics, pressure groups and science do not come up with the best answers.

Instruments

In the early days of laboratory testing we used what were called “wet” chemical methods. Specialist glassware was used to process samples and various chemicals were added, frequently producing a colour that was able to be used to diagnose what was being tested. By the 1960s simple electronic instruments were becoming more common and today they have taken over testing. They can handle hundreds or thousands of samples a day with very little human intervention. Very large and expensive machines are common in the medical field but the cost was a problem at Cawthron. It was always a struggle to find the money to buy essential equipment that could cost hundreds of thousands of dollars. Thankfully small to medium bequests to Cawthron to aid research often went towards equipment. The generosity of these people made many things possible. Among the many instruments we had at that time were a total organic carbon analyser, atomic absorption spectrophotometers, (up to three at one point) gas chromatographs, high pressure liquid chromatograph and ultra violet and infra-red spectrophotometers.

Miscellaneous projects

Blood

As the 1970s progressed the institute was always looking for new commercial projects, however unusual. An ion-exchange resin was developed by a British scientist, Dr R Grant, and a small factory established near the Wakatu estate in Stoke to manufacture it. I think a lot of it was used to extract rennet which is used in the dairy industry and it was initially thought it could be used in places like meat works to clean up effluent that contained proteins. Because one form of the resin could separate proteins we felt it could be used to recover bovine serum albumin (BSA) from waste beef blood at the Alliance freezing works in Stoke. Early trials were promising and a decision was made to work in larger quantities so we lined up with local butchers to collect blood at the works. They wanted it to make black puddings and we wanted to extract BSA. It was a messy project but we did manage to make samples using a combination of the resin and ultrafiltration membranes. This is the same sort used for kidney dialysis. Our director Royd Thornton felt we should patent the process and this was duly done but we were not sure what to do next. Unbeknown to us, Tasman Vaccine Laboratories (TVL) in Wellington had been working on a similar process and was unhappy that Cawthron seemed to have patented their process. Negotiations were held and we agreed to sell them the process. Unfortunately, TVL changed owners and gave up the project so there was no sale and we got no money.

The Environmental and Feasibility Group

My proven record in growing the laboratory services saw me used in other areas. For a few years I oversaw the environmental and feasibility group, but it was never quite my scene. I was more a practical problem solver than an administrator.

I assisted Royd Thornton to prepare Cawthron's first environmental impact report which was into the Karioi pulp mill near Ohakune. The second, also done by Royd with encouragement from me, was on Nelson City Council's Maitai city water dam project.

After this John Bamford took over the group with his wife Lynda working in the water lab. John had previously worked with Ian Baumgart when he was an environmental commissioner.

Under John a wide range of projects were undertaken. Many of these were environmental reports but some were speculative commercial projects.

The environmental work always needed a range of specialists to cover the many differing impacts of an industrial development. Fresh water biologists, road engineers, town planners, water and waste engineers, marine scientists and architects were some of the experts brought in on short term contracts. As the work increased, the institute made some of these positions permanent which helped reshape Cawthron into the organisation it is today.

On the commercial front, Cawthron was involved in the introduction of pepinos to NZ before the project was sold to Duncan and Davies. We also, almost, introduced perfume lavender into the country. France would not allow export of the high grade lavender but

the mother of a staff member living over there had a very close friend who traded in lavender and in this way seedlings and seed were imported. These were planted and bulked up at the back of the institute. When the project finished a lot of this top grade lavender found its way into staff gardens scattered round Nelson.
This group was also involved with planning work in Belize, the Mt Robert and Ohakune ski fields and the Cromwell hydro dam amongst many other projects.

Burner testing
Clean air regulations introduced a requirement for solid fuel burners to meet certain emission standards. In effect, the allowable smoke was proportional to the heat output. The more heat, the more emissions were allowed. We decided to offer a testing service and set up a facility to do the work.
The burner was set up in a special room where the heat output could be measured and the flue carried the smoke through a fireproof bag filter. These bags were weighed before and after the test to determine the smoke particulates, and both the total heat generated and the maximum rate of heat output were recorded. As well, we also did insurance council work where the minimum permissible clearance between the flue and an ordinary wall was determined. I recall that when the burner was run flat out the wall had to stay below 70 degree C. To get maximum heat output we fed the burner small sticks of bone dry eucalyptus wood. Once a fire was going they almost exploded when added and the flue frequently got so hot you could see through it. It must have been near 1000 degree C at times. It seemed a bit dangerous but we never had any problems. Some of the early burners were oversized and I remember one that got up to 30kw output. In the home this was often too hot for the occupants who turned it way down, which made it smoke badly thus defeating the clean air objective. We sometimes got the cast iron burners up near white heat as well. We did this work for many years until we sold the whole thing to Wayne Webley.

Engine Testing
This was a bit out of the ordinary for the institute. It was the time of petrol restrictions and carless days and we had already had some involvement with the fuel business. About a year before the engine project Royd had given his students at the NZ Administrative Staff College near Wellington a project where they had to make business decisions and plans in a world where the use of cars was limited by fuel rationing. Some regarded this as a silly proposition and were reluctant to do the assignment, while other said it would never happen. The introduction of carless days shortly afterwards showed such a scenario was entirely possible. Research on alcohol as an automotive fuel followed some years later.
Cawthron became involved in the area of transportation and fuels when Nelson mayor and institute board member Roy McLennan asked Royd to consider taking an innovative engine designer and builder, Colin Lyster, under our wing and help him develop a new aluminium V8 engine.
We decided to get involved and with money from the Liquid Fuels Trust Board erected a building in the south east corner of Cawthron near the old museum. A large lathe and mill was purchased and Colin set out to cast a solid aluminium V8 block modelled on a short block Chevrolet. A colourful man, Colin had a good track record so we were not totally away with the fairies. He had trained at Rolls Royce in the UK where legendary automotive engineer and Lotus Cars founder Colin Chapman was a class mate. Colin Lyster had raced motorbikes in the Isle of Man TT, designed some of the gear boxes for Jaguar and worked for Ferrari and some prominent Japanese companies. After he came

to NZ he made the motorbike engines for world speedway champ Ivan Mauger and others. It was a serious project but there was never enough money so the payoff was uncertain. The design spec for the engine was for it to produce almost 1000hp but testing it was a problem. We did have a dynamometer but not the high quality linkages to the engine. We were scared to open it out past half power. Rumour has it that it was ultimately put in a jet boat and run on Lake Grassmere where it supposedly exceeded 100mph at less than full throttle. From Cawthron's point of view we got a new building, salaries and a profile out of the project.

Barkers elderberry wine
In the early 1970s we had a little to do with Barkers in Geraldine. I am not sure what we did but they gave us a few bottles of their elderberry wine, which was put in our nice cool chemical store. This was the concrete block building at the back of the institute that was turned into the chip testing lab. Twenty years later I rediscovered the wine and tried a bottle at home. It was one of the best drops I have ever tasted.

Consumer sunscreens
This was one of the first of many jobs we did for Consumers Institute. They wanted to test sunscreens and we agreed to do a user trial in the middle of summer. We used staff and a few friends of friends to get the required number of people and followed a recognised testing procedure. Thin aluminium sheets that covered a person's back had about 25 square holes cut in them measuring about 50mm by 40mm in a grid pattern. These were fitted to the volunteer and different sunscreens applied to each piece of skin within the cut out hole. Skin types were noted. After the person's back was exposed to the sun for a set time, some of the holes were covered up and there was further exposure. Next day the results were read and the differences between products, skin types and exposure times were recorded. It worked very well and Consumer was pleased, but it left our volunteers with grid patterns on their backs for several seasons that stood out when they went to the beach.

Honey research
The Hopkins bequest from an old Nelson beekeeper of some note was not large but the interest Cawthron got on the money allowed us to do a project now and again. In the early 1980s the European Codex Alimentarus became more relevant to NZ exporters because it specified the quality standards required for foodstuffs. Kiwis regarded their food as the best and most natural in the world and we didn't take kindly to Europeans questioning its quality. It came as a jolt when there were problems with our honey exports, which the Auckland-based NZ Honey Marketing Board asked us to investigate. We analysed several NZ honeys to the codex standard and got mixed results. As a fragile unstable commodity, honey has got to be treated right, but it emerged that some producers were still using heat to get it out of the frames rather than centrifugal extractors and were keeping the honey too hot for too long. This was easily fixed but there remained a question mark over the conditions the honey endured during the sea trip to Europe, particularly when it passed through the tropics. We conducted a trial using the Hopkins bequest money to research this issue. Every type of honey produced in NZ was supplied to us. It had been very carefully extracted and samples were stored at different temperatures from freezing to 45 degree C. Sub samples were taken at regular intervals over several months and analysed to see what happened. As expected, not much happened to the frozen ones, but as the temperature rose the rate of degradation increased. Most interestingly, it was only some honeys that were a real

problem. The study provided guidelines for the storage of each variety of honey so they arrived in overseas markets in the best condition.

Fly sprays
One of our larger projects for Consumers Institute involved the testing of domestic fly sprays using an international standard. It was done in conjunction with the DSIR entomology division that leased Cawthron buildings on site. DSIR bred the house flies for us in large numbers and sorted them into the two-day-old females we needed. A set number of the flies were liberated in a room we had built according to the British standard we were following and a fixed quantity of spray released. After a set time the number of flies on the floor were counted and gathered up. They were then put in a recovery chamber where the ones that were not dead recovered. The actual death rate was then measured. This was done many times for each product and the overall results and a report prepared. The project cost about $5000 and involved two to three people for several weeks. This work was repeated several times over the years as new products came on the market.

Hops
The DSIR at Riwaka had developed a line of hops that were very high in alpha acids. These are what makes beer bitter and are often called the bittering principles or humulones by chemists. The usual German hop varieties usually had 4 to 8 per cent alpha acids, while the new NZ ones could get to 20 per cent. While the bittering aspect of these hops was excellent, the aroma was not and the purchaser would blend hops to get the required flavour. Because the price paid to the grower for hops was partially set by their alpha acid content, an independent lab had to determine how much was present in each hop delivery. Cawthron did this for several years.

Watties/NRM animal feed project
Our research scientists were forever working on the conversion of various waste products into something useful. We were very open-minded and almost any starting material was considered. As mentioned elsewhere, a lot of work had been done on wood waste and whey from the dairy industry, mainly to see if they could be used to produce alcohol and/or methane gas. However, we had in mind other useful chemicals as well. During discussions with Watties and the animal feed company NRM, both of whom were regular clients of our technical services people, the idea of converting substantial quantities of vegetable processing waste in Gisborne into animal feed was suggested. It became a long running joint venture with these two companies, involving taking large samples of the various waste lines, such as pea pods, corn cobs and potato peelings, and feeding them through a small pilot plant off site. One Cawthron scientist and an assistant from Gisborne were used and I travelled up on a regular basis.
The project was similar to silage making but a little more complicated. From our point of view it was only partially successful, although the clients were happy enough. We produced the desired product but the economics were questionable and Watties was in the process of being taken over by Heinz.

Closing comments

The Cawthron Trust Board had representatives from the Government, industry and local authorities and these people helped direct work to us. As time passed that word of mouth brought in more business. We offered the right services at the right time so rapid expansion was possible. There were many periods in the 20 years before 1990 when we virtually had a monopoly in some areas.
That changed when several new private testing labs started up and a NZ association of testing labs was formed which I was involved in. Also, the Government was asking departments like the DSIR to start making money as well. This began after Science Minister Bill Birch visited Cawthron and was highly impressed that a scientific research institute was generating a lot of its own income from commercial work. Apparently he went back to Wellington and started to stir things up with government science managers. Royd Thornton said that the next time he went over to Wellington they gave him a hard time for rocking the boat. Anyway, the success of Cawthron did not go unnoticed and I clearly remember one day when senior DSIR people came from Wellington to meet and tell us that they wanted to use us as a model for the commercialisation of parts of the DSIR, which they duly did.
This made it more difficult for us as we had real competition for much of our work and it became increasingly important for Cawthron to carve out clear business niches. There was a history of the Government taking over the work of Cawthron. The soil bureau, entomology and plant disease divisions were all initiated here. While I accept there were good arguments for the Government to do this, it did make life tougher for us. Fortunately, this hasn't stopped Cawthron from continuing to play a vital role in the country's research and development.

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The Cawthron Institute mid 1970's