LUMINOUS MOMENTS

Paul Callaghan

Wanganui has a river crossed by bridges and hills topped by towers. In one of those hills is a tunnel built in 1919, a tunnel with painted arched walls and a repeating line of ceiling lights, striping a path 200 metres into the hill. At the end of the tunnel is an old scissor-trellis door, and a lift that wobbles its way to the hilltop, a lift designed to frighten young boys who have ridden bikes to what seems the centre of the earth. Entering the tunnel, even a slight rustle generates an echo. Noisy boys shout and then wait for the returning voice, more than a second delayed. The experience is magical.

I don't think that as a boy I ever consciously thought about the speed of sound, but I sensed that it had a speed, and that it was slow. Life was full of extraordinary mysteries then. For example, when I was very young, there were the Saturday afternoon movies. My friend Billy thought that there were real cowboys on the stage, and I argued that there weren't, but I didn't quite know how to explain that properly. Dad had a magnifying glass, and my big brother had learned how to make a slide show, with a sheet hanging on the garage wall, and the magnifying glass lens and a light bulb at opposite ends of a wooden apple box with a hole cut by fretsaw that allowed the lens to exactly slot in place. We made our transparencies by drawing frames on a roll of greaseproof paper that we ran through slots on either side of the box and between the bulb and the lens. There seemed to be a special placement of all these parts that made the picture on the screen sharp. Oddly, the transparent paper had to be positioned with the pictures upside down inside the box, if they were to be upright on the screen. All that was a puzzle, but I learned

to make it work. It certainly impressed all the neighbourhood kids who came to the pictures at our garage.

I loved that garage with all the tools and paint tins. I nearly burned it down by throwing fireworks inside, but Dad and my uncle Bill managed to make their way through the flames to get the hose, and so only one end of the garage was burned out. Anyway, Dad nearly burned the house down once, by putting old embers from the fire round the back and too close to the wall. Maybe that's why he was so gentle with me then. But when I dug a really deep hole in the garden and pushed the lawn roller with its huge concrete wheel over the edge, Dad was annoyed. To get the roller out he had to excavate a long sloping ramp from the bottom of the hole to the garden surface, I guess using the same method the Egyptians used to build pyramids. He told me then, 'I hope you have a son who causes you as much trouble as you cause me.' Later, he built me a cart with steering ropes. It went really fast down the hill towards the river. We were so lucky having a river in Wanganui. My friends and I built a boat out of corrugated iron caulked with tar taken from the road sealers. It was OK for a while, but then it sank in the river but that didn't matter because we could all swim.

We had a piano in our house and all of us had piano lessons. At age 10 I started to learn to play the cornet, because some of my older cousins were in a brass band and I wanted to try that. It was amazing that I could play different notes without having to push the valves. Those notes seemed to form the same arpeggio as on the piano. Mum's vacuum cleaner hose worked too, but sounded more like a euphonium, and the sharp ends were hell on my lips. The house was full of fascinating things, like the radio with glass bottles that glowed, and Mum's electric sewing machine that once threw me across the room when I stuck my finger in the empty light socket.

By the time I went to secondary school I had done a lot. I had already seen satellites passing over the sky, and I had built model planes, though never, like some of my friends, proper ones with a propeller and a glow plug motor. I had also built a crystal set. We used diagrams and bits and pieces provided by other kids or bought in model shops. The coil had various places where you could connect the crocodile clip and you had to get the right place to connect before you could select a radio station by moving the comb

of plates that slid inside each other. That sliding part was called the condenser. I liked that word because it reminded me of condensed milk. I could only find two stations though, one very serious that sometimes had Parliament broadcast on it, and one local station with lots of music, like the Everly Brothers and Elvis Presley. To get these two stations I had to string a long aerial wire across the garden between poles, and also connect an earth wire to a metal pole stuck in the garden outside my window. I had no idea why that was. Radio was a mystery.

At secondary school there were chemistry laboratories, and the bright reddish flames of potassium thrown in water. My friend Richard Green knew where to buy chemicals on mail order using our pooled pocket money. Chemistry was about explosives and astonishing colours and strange smells. But physics and mathematics eventually won me over. The echoes of my childhood had posed too many questions begging answers. And physics gave answers, expressed often in the language of mathematics. It also quantified the natural world. By the time I was 17 years old I had measured both the charge and the mass of an electron, using our teacher's brilliant but rudimentary school equipment, incorporating coils of wire similar to that of my crystal set. Rutherford once said, when asked if the electron existed, 'Why, I can see it as plain as that spoon in front of me'. I think I grasped Rutherford's way of 'seeing' way back then. The reality was in the measurement, in the self-consistency of the ideas behind the interpretation. Science had become more than explosions, or the mysteries of crystal sets and magnifying glasses. It had become about a way of seeing the unseeable, of reaching into a world of imagination founded in both measurement and mathematics.

I knew then that I wanted to study physics. But still I really didn't know the thrill of science, the way that science really takes hold of you at the moment that you begin original research and start to discover for yourself. In many ways the years of university training were an interregnum between the playful experiments of childhood and the real research of my early adulthood. I joined a great research laboratory where I cooled atomic nuclei to within a thousanth of a degree of absolute zero, using their gamma ray emissions to see which way they pointed, and randomising their orientations by resonating them with radio waves. The mundane

level of observation, the laboratory connection to it all, was the response of the radiation counter to the sweep of frequency from the radio source. But the reality to me was the complex gyration of the atomic nucleus, a process which I could only grasp through my imagination, and express precisely through mathematics. I cannot explain easily the sensation of that imaginative process, except to say that it thrilled me and placed the everyday life outside the laboratory in an especially happy context. At moments when the creation of some new experiment in my mind brought eventual success in the implementation, the feeling was almost an ecstasy. I remember when I was 36, and I had dreamed up an experiment which, if properly executed using the right radiowave stimulation, would cause subtle nuclear gyrations revealing very slight nuclear shape distortion. It worked perfectly and afterwards I lay awake all night, just reliving the experience, not so much the moment of truth in the lab, but the experience of visualising the atomic nucleus in its dance, of causing it to display its hitherto unseen shape, as well as the electronic environment of the material in which it was immersed.

I think my whole life in science has been uniquely connected to the type of research I do. I have lived in this world of the nucleus, using radiowaves to induce the atomic nucleus to reveal information about its molecular and material environment. To distant relatives and funding agencies I justify this by pointing out all the valuable information I can gather about plastics and food products and plants and people. But the plain truth is, I'm hooked on the world of imagination that the atomic world allows me to enter. I guess if I were a collector of butterflies or a pathfinder for new molecular synthesis, I would be motivated quite differently. I'm quite sure that personality plays a role, that it makes us do the sort of science we do, makes us think the sort of creative thoughts that original science demands. All of us who do science are different personality types. But we all labour under the same discipline. There is always the same tension in the creative process of science.

Richard Feynman once said: 'Our kind of imagination is quite a difficult game. One has to have the imagination to think of something that has never been seen before, never been heard of before. At the same time the thoughts are restricted in a straightjacket, so to speak, limited by the conditions that come from our knowledge of the way nature really is. The problem of creating something which is new,

but which is consistent with everything which has been seen before, is one of extreme difficulty.'

In science, there is a brutal process of judgement that cares nothing for the age, or status or brilliance or track record of the practitioner. Science subjects us to the court of observation, where accordance with reality, consistency with all we know, and ability to go out on the limb of new observational challenges and succeed are all that matter. Scientists can be competitive or cooperative, selfish or considerate, boisterously extrovert or quietly introvert. But one thing they all share is the need to admit, on a regular basis, that they got it wrong.

As part of *Are Angels OK?* I spent many hours talking with both Jo Randerson and Vincent O'Sullivan. They are such very different personalities, as different as any pair of scientists one might meet. Vincent quietly absorbed during our conversations, listening more than talking, his eyes sparkling as I took him around my lab and showed him the things we do, the tools we play with. He was fascinated by elastic fluids, the stuff of the spider's web, and he wanted to read in depth on the subject.

Jo is effervescent and talkative, and we shared a torrent of words, ranging far and wide over many aspects of physics. She was really taken with the idea of 'self-organised criticality', where complex systems poise themselves in apparent stability, broken by bursts of upheaval. The behavioural commonality of avalanches on sandpiles, ecosystem evolution and stock-market fluctuations intrigued her. Jo explores the religious dimensions of life, and we talked about how some natural systems can become so complex that physics can't really describe them in any predictive way, and that led to my acknowledgement that science may have its limits. There is a place for God, if you want that, but I preferred not to go too far down that conversational path. The language just gets in the way. When we physicists speak of 'God', we mean 'the way nature works'. It's a private thing, spirituality.

Although Vincent and Jo never discussed their creative lives explicitly, I would guess that they too live with 'constrained creativity', where the intimidating body of existing literature demands a freshness of approach, an awareness of what has gone before, perhaps, but a need to say something new. Remarkably, Jo and Vincent were fascinated by the world of science, and all the other

physicists had the same experience in their respective conversations with partnered writers. For example, Jo and I found that we were able to talk about quite complex scientific ideas together, though we had to resort to the 'parables' of everyday phenomena. In physics, one can only go so far without mastering the mathematical language by which nature expresses itself. I think, however, that all the writers and physicists shared much in common, as creative people fascinated by the world around them.

And, of course, we scientists are all writers, or at least we need to be writers if we are to communicate our work effectively to the world of science. The truth is that the work of another scientist often seems just as mysterious to us as it can be to the non-scientist. Great science often requires that we express the most subtle and original ideas in simple, compelling prose. Sometimes we try to break out of the straightjacket of precision. Most scientists long to indulge in metaphor, leaping at the chance to speak of 'colour charge', or to name some elementary particles 'quarks', or to refer to the origin of the universe as 'the big bang'. Language, and its power to entice and fascinate, are central to the world of science, and, indeed, I am sure that many are attracted to physics by the desire to become more familiar with the delicious vocabulary of that discipline. Maybe that is true of other branches of science as well, or maybe geologists just like to wander in the mountains and chip at rocks, while entymologists like to collect insects and marvel at nature's bizarre morphologies. While all of science has lovely words, words that intrigue and fascinate, it's not at the heart, it's not the 'nub' of science, in the way that words and their associated feelings and memories are the 'nub' of writing. In the end, however we communicate, whatever motivates us, whatever lured us into our research specialities, we scientists are all ruled by the harsh requirements of accordance with observation. At that moment of truth our literary leanings, our personal characteristics, whether we are wild and passionate or careful and meticulous, all must be submerged. We have to face facts, and face regular failure. That we all share.

At least we scientists may share our burdens, pool our personal traits, and work in common, drawing on our different strengths. For creative writers, the struggle is usually lonely and peculiarly personal. For scientists, we mostly work in teams, indeed almost

always in teams in the case of experimental scientists. And even if, as theorists, we calculate alone, we are motivated to find accordance with the observations of our experimental colleagues. Science is an intensely social activity.

I think that we scientists share with writers the diversity of personality factors and early experiences which determine the almost infinitely varied ways in which we are motivated, in which we create, in which we ply the craft of our work. Those 'echoes of my childhood' resonate in so much that I do. I remain fascinated by the natural world, by its mysteries, by its beautiful phenomena, and by the man-made technologies driven by natural laws. My continual hope is that repeated failures and puzzlement will be punctuated by occasional luminous moments. I think that all the writers here would probably share that hope.

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