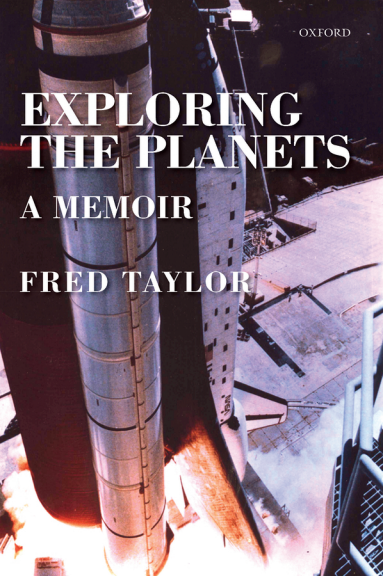




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EXPLORING THE PLANETS

A MEMOIR

FRED TAYLOR

Exploring the Planets

Exploring the Planets

A Memoir



Fred Taylor

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*Dedicated to all the colleagues, friends, and family,
especially Doris, who helped me through all of this.*

If it is the fulfilment of man's primordial dreams to be able to fly, travel with the fish, drill our way beneath the bodies of towering mountains, send messages with godlike speed, see the invisible and hear the distant speak, hear the voices of the dead, be miraculously cured while asleep, see with our own eyes how we will look twenty years after our death, learn in flickering nights thousands of things above and below this earth no one ever knew before; if light, warmth, power, pleasure, comforts, are man's primordial dreams, then present-day research is not only science but sorcery, spells woven from the highest powers of heart and brain, forcing God to open one fold after another of his cloak; a religion whose dogma is permeated and sustained by the hard, courageous, flexible, razor-cold, razor-keen logic of mathematics.

- Robert Musil, *The Man without Qualities*, 1930.

Preface

Space, the Final Frontier

Space travel was my inspiration for over 50 years. It was still on my mind in the summer of 2011 as I contemplated my upcoming retirement from the Halley Chair of Physics at Oxford University. Before me was the mundane task of clearing out the office for my successor and moving to more modest accommodation better suited to my new status. In a lifetime of research, teaching, and administration you accumulate a lot of all kinds of stuff, much of it pre-dating electronic storage media, which means stacks of paper. Eventually time catches up with you, and something has to be done with it all.

I was not actually leaving the Clarendon Laboratory, the old name for the Physics Department which refers to the original building that it had long since outgrown, I was just shifting gears. After such long service as a professor one is usually granted an emeritus position and is free to carry on in one way or another. This brings the delightful prospect of relinquishing all routine duties, while being able to continue to work at the things that still capture one's interest. I could expect to keep some office space granted by my successor as Head of the Atmospheric, Oceanic and Planetary Physics subdepartment, however, emeritus accommodation is inevitably much smaller than the grand professorial office one is used to, and more than likely shared with others. All well and good, but you have to get rid of a lot of your accumulated books and papers.

With this in mind, I started sifting through boxes of paperwork dating back literally to the beginning of the space age with *Sputnik 1* in 1957, when I was 13 years old. I soon realized something that had never quite struck me before. Without specifically setting this as a target, I had participated as a member of one or more of the investigator teams for robotic space missions to every planet in the Solar System, out as far as Saturn, and missions to the Moon and a comet as well. I had a wealth of 'insider' data on each of these missions, all of which had made or were still making history. And I was about to throw a lot of it into the bin.

I paused for thought. If there were young folk out there who had the same sorts of interests and ambitions that I had when starting out 50 years ago, they might be interested in my archives. Just thinking about those I had met and talked to over the years made me realize there must be a lot

of people, not all of them young, who are interested in the first five decades of exploring the planets, and what it was like to be part of it. I lost count of the number of times I had talked about current and historical activities over dinners, at meetings, to the media, including radio and TV, and even to politicians and historians. And yet there was no solid record of any of this except my mounds of dusty letters, memos, and notebooks.

I took the first pile of notes back out of the bin, and a week or two later spoke to the commissioning editor for Oxford University Press about an idea I had hatched. We knew each other because I had written a couple of textbooks for physics undergraduates during the part of my career I had spent on teaching students, but this was something different. I wanted to distil all of the best bits from my lifetime experience and write it up as a book. With the pearls thus preserved for whatever part of posterity might be interested, the oysters could be consigned to the bin without further trepidation.

The Backstairs of History

I knew the Press had published biographies and autobiographies of people like Einstein and various Nobel Prize winners, but they also do them for people who are not quite that famous. The criterion appears to be whether there is a strong and stimulating story line that evolves from a close involvement in something interesting and important. I launched into a description of my first-hand experience of flying scientific instruments to the planets to see what is there, to seek to understand it, and to tell the world what we found when we did. A couple of hours later I left the meeting encouraged to submit a full proposal with a detailed outline and a sample chapter. This was not a complete victory; as an existing author on the Press's books a short description might normally have sufficed, but I agreed that this new endeavour tackled a quite different genre than my ten previous books.

So I started writing, and a few months later found myself contemplating several long reviews of my plan written by no less than six anonymous colleagues whom the Press had approached for their opinions. Leafing through the comments, I could tell from their remarks that these were from people that I had met and knew very well. The responses were all very positive and full of ideas for how the material in the book should be approached. A couple of them questioned some of the minor details in the sample chapter I had prepared about NASA's *Galileo* mission to Jupiter. Obviously, like myself, they had been part of the science team for that big project. They made me realize that relying on memory can be risky when it comes to the dating of otherwise well-remembered events. My dusty notes, diaries, and documents would have to be rigorously consulted throughout the two or three years it took to write, but that was the plan anyway.

This is a memoir and not an autobiography, the difference being that it focuses on the fascinating things I have been fortunate enough to be involved with, which is essentially the entire history to date of Solar System exploration by spacecraft. My own life history is peripheral, but some autobiographical elements have been woven in since they provide essential context. My experiences and views might be of interest to people whose own lives are tangled up with the story in some way, and maybe to those youngsters who share my dreams and want to follow a similar career trajectory.

The Story so Far

The exploration of the planets using spacecraft started when we saw the first views of our Earth as it looks from space, obtained by the TIROS series of satellites in 1960. Even those blurry images caused a revolution in the way we saw our planet. For instance, artistic impressions of the Earth drawn before anyone had seen the real thing always had far too little cloud cover, something that struck me at the time and started my interest in meteorology. Far more important, however, was the way it drove home to all of us the idea that our planet is a tiny, fragile globe hanging in space and not the vast playing field stretching forever in all directions that it had always seemed to us in our everyday living.

The Earth sits in the middle of the Sun's planetary family, with its life support system part of a changeable and changing climate. We depend upon a viable ecosystem but still do not really understand how it works and we cannot control it except in a crude and very limited way. Progress is being made, however, and studies of our home planet by Earth observation satellites in space are playing a large part. This aspect of planetary science—exploring and understanding our own planet—has a special urgency since we have realized that living conditions are changing and threaten the very existence of the human race, or at least its lifestyle.

Probing and monitoring our planet and its environment remains a focus for space scientists, but now we also venture beyond into deep space to deploy satellites and landers on our neighbours Venus and Mars, and send exploratory probes as far away as the rainy lakelands of Saturn's planet-sized moon Titan. The theme of this book is the whys and wherefores of these complex voyages of discovery, from one person's perspective, and the joys and hardships of working to see them achieved. I try to describe the science in user-friendly terms and mostly discuss the 'big picture', in terms of several broad themes. The first of these is what we have learned about the formation of the planetary system, and how it evolved to give us our home world and its range of companion planets we see today. I am particularly obsessed with the conditions on each world, especially their atmospheres and their own

particular versions of weather and climate. Someday we will visit them all, not just with machines and instruments, but in person. We need, therefore, to learn how well conditions suit life, either indigenous (if there is any) or ourselves when we arrive as explorers and colonists.

Playing a part and writing about it

The Space Age is itself now more than 50 years old and for those like me who were lucky enough to get in on it at the beginning, it fills a working lifetime. Today, several instruments that I helped design and build have operated on board satellites orbiting around the Earth and have studied the atmosphere and the climate. In some cases I led the project, with responsibility for big cash budgets and large teams of people. As the technology improved, my colleagues and I branched out to work on ‘deep space’ missions to visit the planets.

Gradually we have become familiar with all of the major bodies (including the Moon and other planetary satellites, asteroids, and comets) of the Solar System, working closely with collaborators in research centres in America and Europe, often using instruments built in our labs at Oxford. Our hardware is now scattered across the Sun’s family of planets out as far as Saturn; we haven’t been formally involved in flights to distant Uranus, remote Neptune, or far-off, icy Pluto, although I’ve worked closely with people who have and had a front row seat from which to watch their story unfold.

The goals of planetary exploration are mostly scientific, but the detailed scholarship in my work is dealt with elsewhere in ‘learned’ journals and books aimed at fellow scientists. A bibliography is available from me that addresses that, for those that want it. This book avoids specialized language and terms and so is for people from all backgrounds who are attracted by space exploration and interested in how and why it is done. You don’t have to be a professional scientist to find the planets fascinating, and to want to know what they are like and what is going on there. Also, of course, everyone cares about planet Earth, and things that affect our daily lives, such as how well we can forecast the weather and whether the climate is really changing.

Often, very little is known to non-participants, whether scientists or not, about how the global space programme has evolved: how the motivations of researchers and politicians can merge to generate the large budgets required; how the technology is planned and developed to make various feats like landing on Mars or flying along with a comet possible; and how often it all goes badly wrong. In setting out to relate the experience, most of the narrative is from my own vantage point and based on involvements I had at the time, at the space agencies, research labs, conferences, and other places as diverse as Cape Canaveral and No. 10 Downing Street. It could be useful to students and others who

want some basic background to the field for their work as well as to interested laypersons. My fellow space scientists might enjoy a different point of view, and even historians might find something of interest in these pages too.

In preparation for writing this book I read a number of other scientific memoirs, looking for examples of erudition and clarity when dealing with topics that include a lot of specialized concepts. It clearly is really difficult to write about complex ventures in space in non-technical terms that make sense to everyone. I have steered my way through, avoiding the minefield of technical terms and concepts, and tried to avoid leaving loose ends. A good model, I found, was James D. Watson's *Avoid Boring People: lessons from a life in science* (2007), in which the co-discoverer of the structure of DNA writes engagingly about his work in a field I don't understand at all, and without boring me, at least, at all. And of course *The Double Helix*, which I read in a single all-day sitting while a student in the 1960s, is a masterpiece I couldn't hope to match, but I can still use it as an inspiration. I also learned from Colin Pillinger's memoir *My Life on Mars* (2010), which overlaps with mine on the science, and John Carey's book *The Unexpected Professor* (2014), which overlaps with me on life as an academic at Oxford.

Hoping for expert guidance I turned to *The Cambridge Companion to Autobiography* (2014). In this I found lots of advice to the aspiring memoir writer, in quotes such as this: 'The "new memoir" aims at truth by shifting perspectives and doubting, fundamentally, the linguistic project of an incomplete mind engaging an infinitesimal subset of functionally infinite reality'. No, I don't understand it either. I hope I haven't done that, whatever it means, but anyone who is confused or confounded by anything I have written, and interested enough to take the trouble to write kindly to me at (fred.taylor@physics.ox.ac.uk), will receive a reply.

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1

Prelude

The Cosmic Grand Tour

For as long as I can remember, and from my earliest years, I was fascinated by the idea of travelling in space and visiting the other planets. I learned to read at a tender age, partly by tackling my grandfather's library of astronomy books, attracted by the pictures, grappling with the captions, and gradually mastering the text. I started to collect my own space-based books and magazines a few years later and began to understand the grown-up material in newspapers. I learned that V2 rockets, no longer instruments of war, were being launched in the New Mexico desert to explore the upper atmosphere, and visionaries were starting to talk seriously about trips to the Moon. I wanted to be part of it. I didn't know how, but I never doubted I would.

I also wanted to travel. A book review of what used to be called the 'Grand Tour' featured in the *New York Times* recently. It began: 'Three hundred years ago, wealthy young Englishmen began taking a post-Oxbridge trek through France and Italy in search of art, culture and the roots of Western civilization.' Visits to the grand capitals of Europe no longer have quite the prestige they had three centuries ago; nowadays most of us have all been to some or even all of them, and to other great cities in the wider world, and the old concept of a character-forming 'Grand Tour' has become more mundane. At the same time, however, new vistas have been opening up, way beyond old Europe and now even beyond the planet on which we live.

The journey described in this book is the story of a modern grand tour that involved voyages through space to the planets of the Solar System, as well as to our Moon, the moons of other planets, the minor planets or asteroids, and most recently to a comet. Except for the incredibly bold Apollo astronauts who walked on the Moon, the travellers were not humans but surrogate robots in the form of specially designed spacecraft, with instruments on board to act as eyes and ears. I was destined to help conceive, design, and build many of these over a period of more than half a century.

I started out on my personal journey just as the space age was beginning, and can now look back on the data we received from these first

robotic explorers in space. They sent back pictures and measurements that revealed bizarre landscapes and scorching or freezing weather that was often riven by storms. Even airless and relatively familiar bodies like the Moon hold mysteries as challenging and exciting as the jungles of Africa did for the explorers of the great Victorian era. The planets were mysterious and fascinating when I set out, but now they seem to me almost as familiar as my own back yard. Exploring them was what I wanted to do when very young, and with great good fortune it really happened, against a background of learning about life, the universe, and everything, on the way.

Published in 1951, my favourite book in my very early years was something called *Rockets, Jets, Guided Missiles, and Space Ships* by Jack Coggins, Fletcher Pratt, and Willey Ley. Profusely and imaginatively illustrated, it stoked a passion, as did its fictional counterparts, none more than *Dan Dare, Pilot of the Future*, a sophisticated comic strip in a magazine for boys called *The Eagle*. The stories were also brilliantly acted out in 15-minute episodes each week night on the pirate radio station Radio Luxembourg, which defied the BBC's monopoly by broadcasting to the UK from overseas. It made money by advertising; Dan Dare was sponsored by Horlicks, a hot drink that was claimed to promote restful sleep if you drank it before going to bed. I didn't like its malty taste, but I drank a lot of it in order to collect the labels so I could join the Dan Dare Space Club and receive the 'authentic' cap badge, which is still proudly displayed with other lifetime trophies in my garage.

The Planets of the Solar System

From Grandfather's library I soon knew all there was to know about the planets, although that wasn't much in those days before space travel. I inherited some of those old books, and now I find them full of erratic speculation on everything except the most basic data about things like size and distance from the Earth. One showed the journey times to the planets if they could be made by fast train (30 years to Venus, the closest), along with a picture of imaginary rails reaching out into space. Those that ventured to describe what conditions were like on the surface of Mars or Jupiter were completely wrong (Jupiter doesn't even have a surface).

Right or wrong, I soon had the details memorized. Six planets are visible to the naked eye and were known to the ancients: dim Mercury, close to the Sun; brilliant Venus, the morning star; our own Earth; baleful, red, intriguing Mars; enormous, colourful Jupiter; and the ringed beauty of Saturn. In addition, our forebears were familiar with the glories of the Moon, of course, and some of the smaller bodies in the Solar System, of which the most spectacular are the comets that appear from time to time, with long tails that trail across the Milky Way.

Our ancestors knew the planets intimately as lights in the sky, but they didn't know much about them as objects to visit. Still, a vast amount of writing has accumulated over the centuries describing conditions on other worlds, in terms ranging from serious, if not always accurate, scientific speculation, to the purely fantastical. Then came the 1960s, when spacecraft started to visit the Moon and the nearby planets, and their true nature began to be revealed. It would not take long, 20 years or so, before probes would be launched that would travel right out to the very edge of the Solar System.

With the large telescopes that became available in the 1800s, the outer ice-giant planets Uranus and Neptune were added to the original six planets known since the earliest times. Uranus is visible to the naked eye, but only just. Also, it moves so slowly across the sky and is so faint that it was not until 1781 that William Herschel recognized it for what it is: a planet four times bigger in diameter than the Earth. Pluto also enjoyed planetary status for a while, after its discovery in 1930, but it no longer qualifies since it is now known to be a member of a large family of small objects, the Kuiper Belt. (Later in the book, I will talk about who Kuiper was, and the time I had dinner with him).

Spacecraft have now visited all eight planets, the closer ones many times. There are all sorts of reasons for wanting to explore, starting with the thrill of the unknown and the wonder of nature, through to gaining new practical knowledge and tracing our origins and planning our future. There is a spiritual dimension to it, too. Learning about new worlds, and the old one, as physical systems, brings with it some insight into the overall meaning of things. This awareness that comes from studying the big picture leads to a kind of secular religion, not always comforting, but realistic in a way that the ancient beliefs are not.

Now that I know what it is like on each of the planets, through studying them with sophisticated devices that have actually been there, I am far from sure I would make the journey across the Solar System in person, even if I could. As a place to live, Mars is the best prospect, but even there we have found an airless, bleak, and frozen desert. Venus is like the Earth, but global warming has raised the temperature so high that some metals, such as lead or tin, melt on its surface. Mercury and the Moon are airless; the outer planets are mostly fluid and have no solid surface except deep in the core. Saturn's moon Titan resembles Earth in many ways and is a decent prospect for a landing party in fifty years' time, but it is far from the Sun and very, very cold.

For me, exciting though it was, exploring these alien environments was not the main incentive for getting involved. It started with looking at our own planet from space, initially to improve weather forecasts (which used to be much worse than they are now, believe me) and then to understand threats like ozone depletion and climate change. Mixed in

with this are some very fundamental questions, like where did the Earth come from, how did it form, has it changed over the aeons, and how did it come to support life?

Answers to questions like these come more easily if you think of the Earth not as an isolated place, but as a member of the Sun's family of planets. They all originated and evolved together, more than four billion years ago, and they all carry historical clues in their atmospheres, their geological records, and their very nature, of their common evolution. Those with atmospheres have weather and climate, which is not the same as the Earth's at first sight, but which under analysis turns out to be just a different mixture of the same chemistry and physics that obeys the same laws everywhere.

Putting all of this together and starting to understand our origins and things important to our survival form the motivation for the journey that my life and career have followed, and that I set out to describe in this book.

Beginnings

Memoirs may dwell on ancestral details, often it seems with tales of city suburbs or tranquil villages where the subject started out, usually either in mansions with manicured lawns and tennis courts, followed by Eton and Oxford, or in abject northern poverty where the whole family lived in two rooms and seldom went out except to work at some back-breaking toil. Mine was something in between. I grew up near the Scottish border, on the Northumbrian coast, almost as far north as you can get and still be in England. For rural beauty and traditional seclusion this area is second to none. But my father's antecedents fished in the cold North Sea and my paternal grandfather, John Henry Taylor, broke his back down an Ashington pit.

I was born in Amble, a pretty seaport at the mouth of the River Coquet. My father's side of the family had been centred there, and at Hauxley, an old fishing village just south of Amble, for as long as anyone knows. On 24 September 1944 the Second World War was still raging. The headline in the Sunday Times for that day is about the Allied attack on the bridges at Arnhem, with the troops arriving in hundreds of gliders; the book and the movie, *A Bridge too Far*, tells the story. My father used his carpentry skills to help to build the gliders, as an invalid, having been seriously wounded and losing an eye in the Army in North Africa during the early stages of the war. It took a decade and several surgical operations before he was fully fit again, and for a time my mother was the breadwinner.

Mother was from Jesmond, a smart suburb of Newcastle upon Tyne. She, and her mother before her, had college diplomas at a time when this was rare for women, and she became an infant school

teacher. When I was five years old, she was offered a headmistress position in the small village of Howick, ten miles north of Amble, on the ancient estates of the Earls Grey. In 1949, when my parents, my sister Maureen, and I arrived, the fifth Earl presided at the stately home up the hill, about a mile away from the village where my mother took over the running of the venerable little two-room school.

The Grey dynasty had been at Howick since the fourteenth century, but did not become really famous until 1801 when the Earldom was created for Charles Grey, who fought with distinction in North America and elsewhere. His son Charles, the second Earl, was a Whig politician, who became (I would argue) the greatest British Prime Minister of all time, since he led the country in 1832 when the Reform Bill was passed, and was still in charge a year later when slavery was abolished throughout the Empire. Thus he was responsible more than any other single individual for introducing modern, enlightened democracy to the country and to the world. Nowadays his name is heard more often in connection with the eponymous tea, which you can sample in the sumptuous tearoom in the former ballroom of the Hall, set amidst the wonderful gardens that you can also enjoy. I visit his tomb in the little church to pay my respects almost every time I visit Howick, which I like to do often.

I have a story about that, which nobody else seems to know. The tomb takes the form of an ornate marble chest, sitting in the nave near the lectern and the front pew used by the Grey family. It is recorded that it once had a fancy canopy, which the fifth Earl so disliked that he personally took a hammer and chisel and broke it up. What is not recorded is that he also had his grandfather's tomb moved, from its original location next to the altar to its present less exalted location. I know this because my father, still convalescing from his war injuries, worked on the estate as a labourer for a time and was part of the workforce that did the job. I remember him telling us about it when he got home in the evening; mainly he was disappointed that there was no sign of the body, which presumably lies deeper in a crypt.

My maternal grandfather was a manager at International Paints Ltd., which had a vast factory complex at Felling on the south bank of the Tyne. He would walk there every day, a round trip of seven miles. His name was Robert Burns, leading me to think (without any palpable evidence) that I might be descended from the family of the great Bard of Ayrshire. Granddad Burns was a cultured man, with a collection of art, books, and music, and his main hobby was astronomy. His beautiful books on the subject, and the extensive collection of science fiction his son, my uncle Alan, built up, including some he had written himself, caught my eye. Fact and fiction merged in my imagination with the prospects offered by the early satellites, *Sputniks* and *Explorers*, that were soon orbiting the world.



The harbour at Amble, now an attractive marina, used to serve the north Northumbrian coalfields as a rail terminus and a loading point for large ships. In the background is the historic castle in the village of Warkworth, where my parents lived after I left home for university. Picture by Anna Williams, Amble Development Trust.



When I was five we moved to Howick, a feudal village in the countryside a few miles up the coast from Amble. The School House where we lived, with the school attached, is seen to the right of Widows' Row near the centre of the picture, with Sea Houses Farm in the background on the coast. To the right, surrounded by trees, is the Old Rectory. The church it used to serve is a mile away, located close to Howick Hall for the convenience of Earl Grey, as was the railway station, now vanished. Picture courtesy of Stewart Sexton.

School Days

I hankered to be an astronomer thereafter, and eventually made it to university thanks to the local grammar school, a wonderful institution that was sadly trashed with much of the rest of the English secondary education system by dogmatic politicians some years later. Every weekday I donned my school uniform and set off along narrow country roads on the big red bus operated by United Automobile Services to the old market square in Alnwick, seven miles away. Alnwick is like a larger version of Howick in that it, too, is dominated by a large aristocratic dwelling. In its case this is Alnwick Castle, home of the Dukes of Northumberland, but now enriched by its fame as the set for Hogwarts in the Harry Potter films. You can visit there, too.

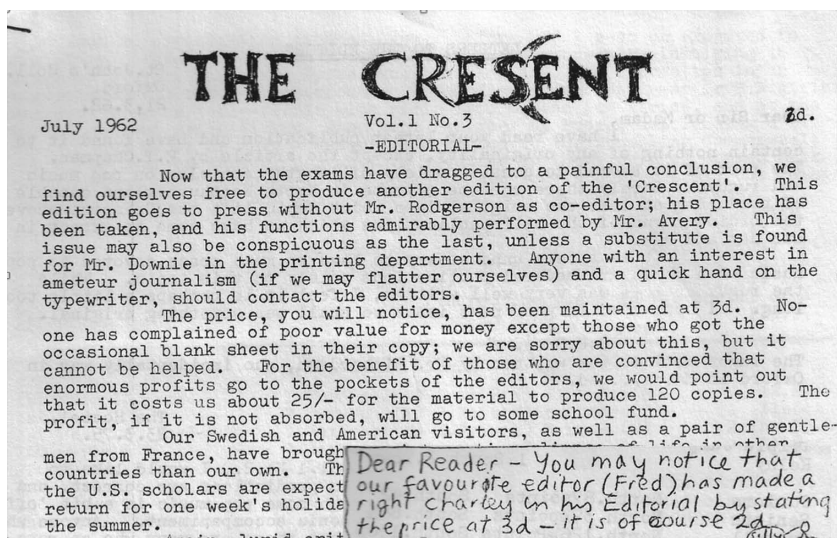
The Duke of Northumberland's School had less than 200 pupils, all boys of course (there was a Duchess's School for girls, strategically located right across the other side of the town) in seven forms from First to Upper Sixth. The buildings were historic, with lavish playing fields, and many of the teachers were wonderful. I was good at my studies and if it weren't for being pretty useless at rugby, cricket, and cross-country running, memories of those halcyon days would have been idyllic. I console myself that my lack of achievement at sport—a non-trivial deficiency at an all-boys school, although prowess in the classroom leads to grudging respect from one's peers that mostly saves the day—was mainly due to a deep-rooted lack of interest in what I saw as unproductive effort and pointless aggression.



While still very young I acquired this crumbling wall chart, made more than a century ago by my grandfather Robert Burns (d. 1962), on the back of a picture of the Tyneside factory of Holzapfels Limited where he worked. The date is before 1914, because the German name was changed to International Paints Ltd when the First World War started.

At home, the local boys, about half a dozen of us, played a rudimentary version of soccer in the fields around Howick and I enjoyed that, but football wasn't allowed at school, it had to be rugby. I think this was to be consistent with schools like Eton, where soccer, once popular, had long since fallen out of favour. I thought and still think rugby is an awful game, maybe because I was tall and heavy and so assigned to play as a prop in the middle of the scrum, an uncomfortable and undignified role in an uncouth and pointless ritual. I soon broke my arm by trying too hard to get into the swing of it, which was a blessing because then I didn't have to play anymore. I took up the javelin and shot-putting instead and achieved a modicum of competence at both. I was even better at chess. Nowadays I enjoy *watching* cricket and football, in the spirit of a Roman emperor watching slaves duel to the death, especially with HD TV which reveals exactly what's going on and slow-motion replays that allow you to savour the details.

More of a success than my sporting endeavours was my role as originator and editor of the school newspaper, *The Crescent*. The name came from the school badge, which featured a crescent and fetlocks taken from a banner that an early lord of Alnwick Castle, Sir Hugh de Perce, brought back from the Crusades. My co-editor 'Tiny' Rodgeron, so called because he was large, couldn't spell crescent and so the masthead said 'The Cresen't', with a large symbolic crescent moon belatedly superimposed behind and falling between the s and the second e.



The front page of an early issue of the Duke's School newsletter, 'The Crescent', which I edited, and a 'note added in proof' from the back. For some reason we thought it was a rather professional production at the time. It was printed by an antiquated and very messy process called cyclostyling.

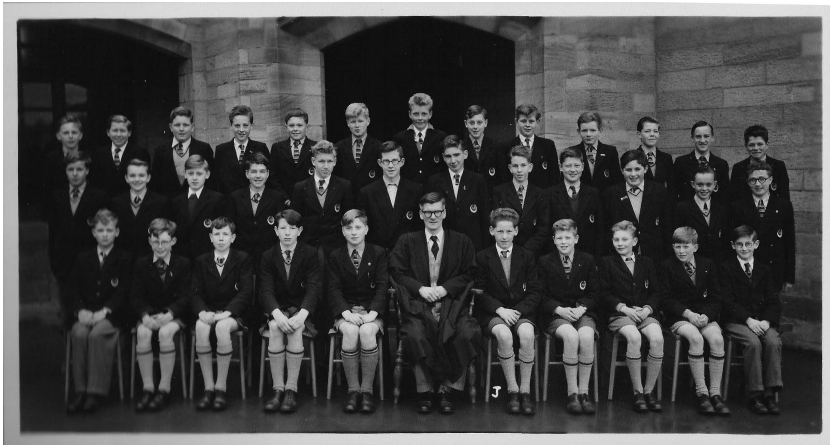
The venture went a little sour when we wrote and published a satirical play to fill the space at a time of little news. One of the subjects of the satire was the Headmaster, to whom we attributed the following lines, where he admonishes a delinquent pupil thus:

‘Avast! Avast! You scurvy knave. Thou shalt not be the winner.

I have a horrid fate for thee. I’ll make thee eat school dinner.’

The problem was not so much the Head, who took this sort of thing in his stride, as the Chef, who took great exception to this slur and reportedly threatened to resign. Although I confessed to writing this piece of deathless verse, for some reason the punishment fell mainly on Tiny, who refused to take any further part in writing or publishing *The Cres(c)ent*.

The Duke’s School had been founded nearly 200 years earlier as the successor to an older school in a building that is now the town library. We were old enough to have our own traditions, but our school song, *Forty Years On*, was the same as Harrow’s, and we had slang terms for everything like boys at an archetypal public school do. We also had flogging, although only for serious offences like smoking in the old air raid shelters, planting fireworks on a slow fuse that went off in the drains during the French class, or attempting to manufacture dynamite in the woodland that surrounded the playing fields, to mention three examples that brought retribution on me personally. Even then it was perfunctory and relatively mild, obviously intended to administer a minor humiliation as punishment rather than actual pain.



The 2nd Form at the Duke’s School, Alnwick, in 1958. The form master is Mr Alan Dodds.

English and chemistry were taught with passion and flair by Messrs Joseph Grieve and Arthur Bell respectively. Inspirational and supportive teachers like these have and always will make all the difference to young people's dreams and aspirations. I recall Mr Grieve saying 'Northumbrians are low achievers in general because they never put themselves forward. Learn to speak properly, and to be just a little bit pushy, and you'll be fine.' This I thought reminiscent of Lord Byron's comment about Edward Trelawny, 'if only we could get him to wash his hands and tell the truth, he would have the makings of a gentleman', but Joe's advice was more kindly meant. Mr Bell offered me a job as his lab assistant, which involved real responsibility and an income, both extremely modest, but novel and edifying concepts to me.

These two of my favourite teachers came together to suggest that I entered a competition that one of them had found in a magazine held in the school library. The challenge was to describe some topic in modern science using the language of Chaucer. We were deep into *The Canterbury Tales* with Mr Grieve at the time, and Mr Bell was fascinated by the new technology just arriving in the form of electronic computers. For my part, I was riveted by the serial *A for Andromeda* on BBC television at about this time, in which the plot focussed on a computer built following instructions from outer space. The story had been written by Fred Hoyle, a professor at Cambridge who was already a role model for me, and starred a stunning 19-year-old Julie Christie as a beautiful alien.

So I wrote in medieval terms about a computer, and I won a prize. A bit of passion obviously goes a long way, because the only previous time I had won anything like this was as a fan of the great children's author Enid Blyton while still at junior school. She edited her own magazine for a time, with a monthly competition in which I won an autographed copy of her latest 'Famous Five' book, which I still treasure. What I did to win that I have long forgotten, but my successful Chaucerian verse appeared in the magazine, and the final stanza ran thus:

*To gette ye anser to a questione si fowle
Would take ten menne a lifetime, were they wize as an owle!
And so you must see oure terrible plite
For noone doth know if our computer is rite!*

Chaucer must have spun in his grave.

Although English and Chemistry were my best and favourite subjects at school, clearly neither offered the pathway into space that I wanted. Mr Laidler's physics lessons were OK, but it takes a certain sort of brain to enjoy maths, and I didn't, which is unfortunate since a talent for maths is generally taken to be a *sine qua non* for physics, too. On the other hand, I read that Ernest Rutherford, perhaps the greatest experimental physicist of the twentieth century, was notoriously poor at maths and would fumble derivations of formulae during his lectures at Cambridge. Encouraged by this, I thought I could manage a degree

in astronomy as a way into space research, especially if I could stick to the experimental side. Then I would follow my urge to join those lucky few who were paid for designing and building rockets and spacecraft.

The Headmaster of the Duke's School was a magisterial, and to the pupils terrifying, figure called Frank Mosby MA, known to us, although not to his face, as The Gaff. I recently unearthed the fact that Mosby had become Headmaster at Alnwick the month I was born, September 1944. The same internet search uncovered a large engraved silver platter, presented to him on his retirement in 1969, rather pathetically up for sale on eBay. *Sic transit gloria mundi*. But in 1962 when I meekly described my goals and plans to him, the Gaff listened carefully, and then spoke wisely. 'Forget the degree in Astronomy', he said, 'you'll end up on top of a mountain somewhere, even if you are lucky enough to get one of the few jobs that are going. Get a degree in a basic subject instead, like Physics, then specialize later.' This was excellent advice and I never regretted that I opted to follow it.

But where to apply? There were very few Astronomy degree courses, but nearly every university that existed then offered Physics. I was briefly tempted by Keele, which was then quite avant-garde in its degree subjects and had a course called Physics with English. 'No, no' said the Gaff, 'do it properly.' He wanted me to stay on at school an extra year as a one-man 3rd-year sixth form, with the express goal of taking the Oxford entrance exams. I would also have to obtain the required qualifications in Latin or Greek, then mandatory at Oxbridge even for students taking science degrees. I had done four years of Latin at school already, and a pass in the Latin exam would have been a formality, but the idea of another year at school, with all my friends gone (not to university, most of them; only a small percentage of the population took higher education in those days) was anathema.

One fine day I won a scholarship to participate in something called *the 6th International Youth Science Fortnight*. This was based in London, and was a stunning affair aimed at future scientists that involved inspirational talks and numerous visits to institutions and companies. The Duke of Edinburgh was a sponsor and I met him at an event organized for us at the National Maritime Museum in Greenwich. We also went to iconic places like Shell, Esso, English Electric, Bradwell nuclear power station, and the (slightly less ephemeral) House of Commons at Westminster. On one of the free evenings I took myself to the West End and saw the first run of the musical *Oliver!* with the fabulous Georgia Brown as Nancy. Her rendering of 'As long as he needs me' still makes my toes curl when I watch it on YouTube.

One of the daytime visits for Science Fortnight participants involved a trip to Oxford, where I unwittingly visited my future home, the Clarendon Laboratory. I was not much attracted by what we saw there, a lot of congested laboratories with benches of polished wood loaded with strange equipment, electromagnets, and early types of lasers. Small, bent, serious-looking men in three-piece suits or white coats, and

sometimes both, scuttled like rats down gloomy corridors. I remember ascending to the top of the tallest building in the city, the new Biochemistry tower, which by contrast with the Clarendon was light and airy, but then still unfinished and unoccupied. As I write now, 50 years on, the tower is being demolished. I am not the first writer to remark that few things make you feel older than seeing them tear down a building that you also watched them build.

In spite of the fact that we were shown departments that included trendy subjects like Biochemistry, clustered around the Natural History Museum with its strange collections of dinosaurs and crystals, the atmosphere at Oxford seemed to me that of a place whose achievements in the humanities soared over everything else, including science. The research in physics seemed to be all about properties of matter, or nuclear physics using their own in-house particle accelerator. I did not know then, nor did anyone tell our little group of sixth-formers as we shuffled around the labs, about the pioneering work that was going on there using aircraft to study ozone and water vapour in the stratosphere. Even if I had been aware of its existence, there was then no clue that the small meteorology group in the Clarendon lab was poised to move into space research just a year or so later. Had I known that, I might have been tempted into spending another year at school to take the Oxford entrance exams. On the other hand, I did know that it was far from certain that I would get in, and then I would have spent a lonely year as the only member of the 3rd-year sixth form for nothing.

University

So, where to apply? In the end it was no contest. I narrowed it down to the five great northern universities with strong Physics departments, then quickly eliminated Newcastle because it was too close to home. Manchester had probably the best academic reputation, but this was 1963 and I was 19 years old: work and a career was one thing, but not everything, and so far as life beyond work was concerned Liverpool was the centre of the universe. The Mersey Sound was in its heyday, I knew the social life would be fantastic, and it was.

I duly applied and Liverpool took me on. The Physics Department was excellent, with really good lectures and well-equipped practical labs, and even a tutorial system which, looking back on it, was every bit as good as the renowned system at Oxford. That is, if you lived in one of the Halls of Residence. Places in Hall were scarce, and many of my fellow physics students lived in lonely digs scattered around the city, often just a spare room in somebody's house, possibly not even in Liverpool itself but across the Mersey in Birkenhead, requiring a ferry crossing every day. Hall, in contrast, was not too different from an Oxford college, offering an attractive environment with communal dining and additional support in the form of resident 'moral' tutors.

The idea of a moral tutor may sound appalling but I had every reason to be glad of mine, especially at the beginning when I was trying to find my feet, and near the end when exam pressure almost became too much. The rest of the time they didn't interfere except to occasionally dispense sherry and small talk similar to the approved Oxbridge fashion. The tutors in the Physics Department were indispensable too. Physics at Liverpool was a four-year course, but if your qualifications were good enough you were able to skip the first year and enter straight into the second, which is what I did. I suppose the assumption was that you would soon catch up on the basic material, and eventually I did, but coming on top of the trauma of being away from home for the first time it wasn't easy, especially the maths. I flunked a test for the first and last time in my life and was greatly upset, but the tutorial system kicked in and saw me through. After six months or so it was fine.

I was lucky enough to spend the whole three years in Rathbone Hall, indisputably the best of the student residences both in terms of facilities and reputation. It was located several miles from the main campus, at one end of soon-to-be legendary Penny Lane. It was single-sex, of course, despite this being Larkin's *Annus Mirabilis*, the year of the Beatles' first LP. Each resident had a decent room, not en-suite but with the luxury for the time of a wardrobe and a wash basin (which, by common consent, could double as a urinal so long as the water was left running). Set in the spacious grounds of Greenbank Hall, it provided excellent,



The residents of the top floor of D block at Rathbone Hall in 1965. L to R, Back Row: Terry Wright; Derek Senior; Dick Carver; Bob Lawless; Phil Ayres; Front Row: Fred Taylor; Dave Wilson; Geoff Crowther; Talib Al-Hadithi, Mike Maddocks. The windows behind Phil are those of the Common Room, home to the student bar, over which I had charge.

abundant meals prepared by young women training for a diploma in catering at a nearby college of further education, a laundry run by nuns, and of course unlimited fellowship. Perhaps most important of all, the Hall had its own bar, run by students, open two nights a week.

The rooms were heated but, if you wanted to be warmer or make toast, there was a small electric fire built into the wall. This ran on a meter, which took shilling coins; we soon discovered that it was a simple matter to prise open the locked coin tray and use the same coin again. Of course that was soon rectified when we foolishly killed the golden goose by leaving just one shilling in the tray at the end of term. The Bursar ordered the meters wired shut and that was that. The strange thing to me, looking back, was that we never for a second thought there was anything illegal or immoral in what we did; if we thought about it at all, we thought the electric fire should come with the rent.

A State Funeral

On 29 January 1965 I joined three of my fellow physics undergraduates on an epic and audacious journey. We had resolved to travel to London for the state funeral of Sir Winston Churchill the next day, reasoning that this was an historic event without precedent that we would always remember, and so it proved. We piled into Geoff White's elderly Ford Anglia and set off in the evening, travelling all night in the freezing cold on mostly pre-motorway roads that passed through many a town centre on the way. We arrived as planned just as dawn was breaking and found a good vantage point near St Paul's Cathedral and settled there for a long wait in near-Arctic conditions. Contemporary newspaper reports said that the temperature was -5°C , and it felt like it. Gradually, statesmen from every nation in the world assembled, and finally the Queen arrived.

After the ceremony was over and the long cortege had gone by, with the coffin on a hand-drawn gun carriage, heading for the Thames and from the boat to Waterloo Station for the funeral train to Long Hanborough near Blenheim Palace, the crowd began to break up. Starving and freezing, we found a pub for lunch, and then wandered around Soho for several hours. Given its racy reputation, it was a disappointing and anti-climatic venue. As darkness fell we retrieved the car from the side street where we had left it, and started the long trek home, arriving back in Liverpool the next morning, tired but elated by the adventure.

Jodrell Bank

During the long vacation at the end of my first year at Liverpool I applied for a place on the Summer School that was run each year at the

radio astronomy laboratory at Jodrell Bank in Cheshire. This had been founded in 1945 by Sir Bernard Lovell, a near-legendary figure in British astronomy who was still around in 1964 when I arrived there, and friendly if a little vague and remote. He, and the rest of the staff, gave us inspirational lectures, showed us over their world-class hardware, including the huge 75-metre dish for which the site was famous, and gave us a few menial tasks as an introduction to experimental research. I soldered together a power supply intended for a new receiver that would amplify the signals from space. It looked awful and resisted all my attempts to make it work; I imagine that someone with more experience than I had of assembling electronic circuits rebuilt it after I left.

I enjoyed the visit, but it put me off any idea I had of trying to get in there to do a research degree. The place was isolated and the work mostly unglamorous despite its far-sighted horizons. But worst of all, they used their fame to recruit far more graduate students than they had money, work, or room for. Around 20 were taken on each summer, bright-eyed and hopeful that they would earn a doctoral degree. However, all but two or three were shed at the end of the first year with only a master's degree to take into the outside world. Many years later, the subject of Jodrell came up when I was sitting on a committee with Chris Rapley, a highly accomplished near-contemporary of mine who later became Director of the British Antarctic Survey. It turned out that Chris had fallen victim to their semi-scrupulous recruitment approach a few years after I was there. I don't think he ever forgave them.

Running the Bar

Back in Liverpool, I completed the first two years of study and finally learned some maths. My biggest problem now was where to live; accommodation in halls of residence remained over-subscribed and the rules said that you had to move out after a maximum of two years in order to make room for new arrivals. Desperate to avoid having to live in the dreaded 'digs', I secured a rare third year in Rathbone Hall by conspiring to get elected to the student committee as Bar Secretary. In spite of the odd title (more than one of my contemporaries thought it hilarious to refer to me as a bar steward) the position involved responsibility for the actual running of the student bar, which opened two evenings a week. I ordered stock, appointed barmen, and arrange special deliveries for individual parties, all at knock-down student prices. This was my third taste of part-time management and commerce, and rather a harrowing experience for all sorts of reasons, but again excellent training in man-management (by which I mean finding out how difficult it is, not necessarily becoming good at it).

One of my dubious achievements during my year in charge of the bar was to introduce barrels of strong scrumpy, which was ludicrously cheap compared to beer, and led to cases of students being sick in inappropriate places, a crime which enraged the Warden, a normally amiable man called Donald Coult, who held me responsible (it being difficult to identify the actual perpetrator from the evidence alone). I responded by jacking up the price of scrumpy to the point where consumption fell (and the bar made a massive profit), but this so enraged the clientele that in the end we had to quietly drop the stuff from the tariff altogether.

With the post of Bar Secretary came a position on the governing body of the Hall, and I also took on the editorship of the *Rathbone*



Views of the observatory at Jodrell Bank in Cheshire, where I spent the summer vacation of 1964. Two of them are taken from high up in the structure of the 'Mk. 1' radio telescope, whose big dish can be seen in the picture at top right, behind the hut where I worked. The smaller but more modern Mk. 2 is bottom left and a small dish, used for satellite communications, is in three of the shots.

Record, the Hall's student magazine. Having been co-editor of the school newsletter at the Duke's School, I had found that sort of thing rather suited me. Glancing at a faded copy of the *Record* now, I see on the back page a report on a football match in which I played for Rathbone against a team of medics. The reporter describes me as having 'recently been turned down by Liverpool and Everton, as well as every other football club to which he applied', and turning in a performance 'reminiscent of a three-legged horse'. Still no good at sports, then.

Journalism really was my thing, however. I joined the staff of the *Panto Bulletin*, the university-wide student newspaper that focussed on the year-long build-up to what in universities elsewhere was known as Rag Week. In the climax to Panto Week, students haul huge floats through the streets of Liverpool and compete for the prize of free attendance at the grand ball that rounds out the week. Rathbone had won the previous year with a giant beetle, carrying look-alikes of the Fab Four on top and playing their music loudly. Wearing black tights borrowed from the girls' physical fitness academy at Bark Hill, I played the part of two of the insect's legs, supporting the incredibly heavy structure based on scaffolding borrowed from a building site.

In 1966 we won again, hauling a giant cannon inspired by the film *The Pride and the Passion*, set in the Napoleonic wars and starring Gary Cooper and Sophia Loren, which had been very popular a few years earlier. As we trudged down Ranelagh Street I was glad to be in the open air this time and able to see around me; also not to be deafened by huge speakers repeatedly blasting out *She Loves You* and *I Feel Fine* a few inches behind my head. Back at the *Bulletin* office, we commissioned a fund-raising extended play record featuring the Roadrunners, a popular local group once favourably compared to the Rolling Stones by no less a critic than George Harrison. The star track was their own upbeat, contemporary version of the folk song *The Leaving of Liverpool*.

Getting the work-play balance right was a bit of a challenge. There were many excellent parties, most famously at no. 9 Mossley Hill Drive, on the edge of Sefton Park. Local groups, aspiring to fame (and later making it, in a few cases) would play at your party all evening for £10 and some free beer. The Student's Union hosted many of the top groups from outside Liverpool; I remember dancing to Gene Vincent and the Bluecaps, Eric Burdon and the Animals, and even Screaming Lord Sutch. Sutch is mainly remembered these days for founding the Monster Raving Loony political party, which still contests most major elections in the UK, but he did have a chart success in the 60s with 'Jack the Ripper', despite (or perhaps because of) the fact that it was banned by the BBC, which used to regard itself as the keeper of the nation's morals. On stage, Sutch would perform a long version of his big hit with great gusto, including a lurid pantomime of the original Ripper's criminal acts.



Student Panto week at Liverpool, 1966. I am at the front of the phalanx on the right in sackcloth and a burned-cork moustache towing the prize-winning Rathbone Hall float, 'The Pride and the Passion'.

At the clubs in the centre of town you paid a small fee for membership but then got to dance to groups that were just hitting the national charts, like the Searchers. Most of them had rotating multi-faceted crystal balls on the ceiling that reflected shafts of coloured light, and ultra-violet lamps that made your shirt, and your dandruff, glow brightly in the gloom. Men still wore white shirts, jackets, and ties to go out then, and the girls nice dresses, even to grimy, sweaty, airless dives like the Cavern. This was the real Cavern—the one they take you to now is a replica, recreated where the original lies underground, filled in by bulldozers. Just as well—I'm sure the new one is more sanitary.

Looking for a Doctorate

During the build-up to our final exams, a few of us were called, one at a time, into the office of Professor Leslie Green, high in the tower of the Physics building. When my turn came he told me he thought I would do sufficiently well in the final exams to qualify to do a PhD, and would I like to think about nuclear physics research at Liverpool and the nearby government research facility at Daresbury? This vote of confidence gave me a nice lift at a time of great stress, but I had my eye on space research and the sub-atomic stuff they did at Daresbury (where

Professor Green would later become Director) did not have the same appeal. I had read about the Space Science Laboratory at the University of London, and I was targeting that.

But one day, as I left the building after a session in the practical laboratory and passed through the ground-floor lobby, now empty and echoing as it was late afternoon, I stopped to look at the student notice board. It was covered with eye-catching posters offering job opportunities to freshly minted graduates, and I almost missed the small postcard on which a few words were typed: Doctoral opportunities to work on a new Earth satellite experiment: contact Dr John Houghton, Reader in Atmospheric Physics at the Clarendon Laboratory, Oxford. So now there was space research at Oxford as well!

I wrote to Oxford and was invited to come and learn more at an interview. I motored down from Liverpool in my elderly and unreliable Austin A30. Its nickname, *Thunderball*, was discreetly stencilled on the front wings, my old air pistol was concealed under the dashboard, on which a row of switches labelled ejector seat, overdrive, and supercharger, mimicked Q's gadgets but were not actually connected to anything. The mechanic at the filling station on Smithdown Road, where I had earlier taken it for the compulsory MoT roadworthiness test, impishly told me it had failed. 'Why', I asked miserably, contemplating a swingeing repair bill. 'Some of the accessories don't work', he said.

Yes, this was the era when every young man wanted to be James Bond and I lusted after, but could not afford, an Aston Martin. *Thunderball* had hung on to life and gave good service around Liverpool, but the gearbox finally gave up the ghost on the way back from Oxford, somewhere around Wolverhampton, at 10pm on a cold March night. I flagged down a police car (the police were friendlier in those days, and even managed to be cordial about the fact that my road tax disc had expired) which led to a mechanic arriving and rigging up a temporary fix that got me home in the small hours.

This longer encounter, and the discovery that my dream subject was available, led me to completely revise the view of Oxford that I had formed on my brief schoolboy visit as part of the Schools Science Fortnight. I found the Atmospheric Physics department tucked away at the back of the main physics laboratory, the Clarendon. It was small, cramped, and intimate, but since the arrival of John Houghton as its leader it was already on the way to putting its first instrument into space on an American satellite. Previously, the group had mainly worked on observing stratospheric ozone from the ground, and stratospheric water vapour from aircraft, in both cases by making spectroscopic measurements of the atmospheric path between the instrument and the Sun. John had worked out new ways of making similar measurements from space, so that the whole planet could be observed all of the time, rather than just at a few isolated locations, and had successfully sold NASA on the idea.

The town was delightful and the university humming with life and, although it still definitely had one foot in the past, the other was now seen to be just as clearly in the future. I stayed in a guest room in Jesus College and was taken to dinner by one of Dr Houghton's current doctoral students, David Pick. 'You can order pints of beer with dinner' I wrote home excitedly, 'and they bring you breakfast in bed.' At least this was the promise, but in the event the 'scout' who would have brought it woke me up and asked if I would mind going to the hall with the students, because 'the old gentleman in the other guest room had passed away in the night, sir'.

The two guest bedrooms shared a common sitting room, through which we both had to pass to get to the staircase. My neighbour was an elderly, distinguished judge and colonial administrator, Sir John Blake-Reed OBE. He had served mainly in Egypt and became a Grand Officer of the Order of the Nile, an honour he shared with Queen Elizabeth II, Haile Selassie, and Nelson Mandela, among others. Educated at Jesus and now an honorary fellow, in addition to his legal work he published his own translation of the odes of Horace, 'capturing, in no small measure, the spirit of the original . . . where so many have failed', according to a contemporary review published in Cambridge in 1948. He was asleep (as I thought) in one of the armchairs when I came back from dinner. I tiptoed past and went to bed. In the morning, as I headed to the hall for breakfast, I passed the chair and its occupant covered by a large white sheet. Curiously, this bizarre episode did not really seem out of place among the ancient stones and halls of Oxford.

After the interview Dr Houghton said he would accept me as a doctoral student. However, I still had to gain formal admission to Oxford, and a grant to pay my fees and living expenses. This would require a good grade in my final exams at Liverpool, which were still to come. Back on Merseyside, I worked myself into the ground, getting up at 5am to study and forgoing the bar where my friends would gather in the evenings. Minutes before the barman called last orders, I would arrive just in time to gulp one pint and order another before they closed at 10.30, as required by law then. Nowadays, the student bar at the former Oxford Polytechnic, now Brookes University, which is near my home, closes at 2am.

I still had to show up at Rathbone bar, being in charge, but it only opened two evenings a week, and I had an army of helpers, some of whom were actually competent. Most evenings we went to Greenbank House, a redundant stately home in whose grounds Rathbone Hall had been built and which was now a recreation centre for students, with a lively bar that was open seven nights. Greenbank had been the home of the Rathbone family, a prominent local dynasty whose wealth derived mainly from trading with America from the port of Liverpool, from 1788 until 1944 when the house was donated to the University. Today, it stands derelict.