PROLOGUE

During the nineteenth century, savants in England continuously improved the science of astronomy, bringing it to a high professional level by the end of Queen Victoria's reign.

In January 1820, fourteen gentlemen and scholars, one of them the future computer pioneer Charles Babbage, had founded the Royal Astronomical Society, which received its Royal Charter from King William IV in 1831. Sir William Herschel, the discoverer of Uranus, the builder of giant telescopes and the most accomplished sidereal observer of his age, became the society's first president. In 1834, the British government provided the society with suitable premises free of charge, an arrangement that continued uninterrupted until 2004. The universities of Oxford and Cambridge had important observatories from 1794 and 1823 respectively, together with endowed professorships. At Greenwich, the Royal Observatory, one of the world's oldest scientific institutions, flourished in the age of Queen Victoria, and was noted for its accurate observations of the positions of stars. In 1884, an international conference in Washington, DC, convoked by President Chester Arthur of the United States, selected Greenwich as the world's prime meridian.

By the early twentieth century, British astronomy could hold its head high: a small community of professionals at the Royal Observatories and in the ancient universities conducted world-class research. Furthermore, they encouraged the development of astronomy in the dominions of the British Empire, with the establishment of observatories in Australia, Canada and South Africa, where the practitioners still looked to Greenwich for guidance.

After World War I, observational astronomers in the United States began to advance on their British colleagues. By 1917, the Americans had the world's largest telescope, the 100-inch reflector at Mount Wilson, as well as far superior observing conditions and generous funding from curious philanthropists. Britain, meanwhile, had suffered the dreadful slaughter of her young men in the war, followed by a deep and prolonged economic catastrophe, the slump. Although there were golden years for the physicists, particularly those in Cambridge, who won a string of Nobel prizes by prising open the atom and its nucleus for their inner secrets, astronomy

was in decline. British astronomy suffered from a failure to invest in new telescopes at home, as well as a distinct lack of enthusiasm for the long sea voyages needed to reach the cloudless skies of His Majesty's dominions. In 1944, with the untimely death of Sir Arthur Eddington, British theoretical astronomy lost the brightest astrophysicist of his generation.

Defence research during World War II drained the young talent from Britain's dozen or so better universities. Pure research in physics and mathematics became the pursuit of the older men who had survived the killing fields of the Somme in the previous conflict. A certain amount of astronomical research continued at bomb-damaged Greenwich because of the Royal Navy's requirement to maintain the expertise of astronomers for navigational and time-keeping purposes. When the university scientists were finally released from their secret war, they returned to laboratories and faculty buildings overflowing with students whose education had been suspended during the war. Furthermore, yet another economic crisis led to severe shortages of food, fuel and equipment. By the middle of the twentieth century, astronomy in the United States was far ahead of that of Great Britain. The 200-inch telescope at Palomar had commenced observations in 1948, research on atomic weapons had produced highly trained teams of experimenters and theorists, the electronics industry was thriving and the fledgling computer industry was rapidly growing.

Fred Hoyle and his contemporaries completely transformed British astronomy in the quarter century beginning about 1950. By turns, Fred Hoyle startled and charmed his public with a copious stream of new ideas, implausible theories and an innovative approach to research. While most of his professional colleagues specialized in a single area of research, such as comets, or the evolution of stars, or the nature of sunspots, Hoyle's approach had more in common with the leading intellectuals of the Enlightenment. He regarded the entire celestial realm – the universe and all its contents no less – as being within the compass of his enquiries. Naturally, this would bring him in conflict with those members of the academy who had a strong sense of ownership of their respective specialities.

By his example, he led a despondent research community away from a fading tradition, directing them instead toward the extraordinary richness and diversity of the new astrophysics that began to emerge in the 1960s. In the 1970s, thanks in good measure to his inspiration as well as his considerable skill during the short period in which he directed, at the national

level, the policy for astronomy research, Britain again became a world leader in the astronomical sciences. Many other distinguished astronomers played an equal, and some a superior, role to Hoyle's in advancing research expertise, thereby recovering Britain's international prestige. Such a claim is certainly true of Britain's radio astronomers, Britain's space research community and those applied mathematicians who chose astrophysics and cosmology as their research areas. It is also important to recognize that the professional community as a whole, working through both the Royal Astronomical Society and the funding agencies, persuaded successive governments to increase the provision for jobs, new telescopes and expensive space missions. Hoyle's personal contribution to the rebirth of British astronomy came from his outstanding ability to think outside the box, and his unfailing loyalty to international collaborations at a time when many British researchers regarded American astronomers as the competition rather than an opportunity.

An enduring feature of Hoyle's character was that in every sense he never let setbacks, rejections or political manoeuvres deflect him from his own research agenda. He always had a deep conviction that in his 'search for the truth', which is how he expressed his life's mission, any opponent should be able to provide a counter-argument from experiment or direct observation. He declined all opposition based on semantic arguments invoking the philosophy of science, or the deployment of a paradigm, or appeals to common sense. After all, as an undergraduate he had learned general relativity and quantum mechanics from two masters, Eddington and Paul Dirac. From both professors, he understood that accepting what is obvious could not enable him to discover the nature of the physical world.

After 1950, Fred Hoyle was a very public figure at home and abroad. In the 1960s, 'according to Hoyle', originally applied to the rules for card games, became a catch phrase in discussions of the latest news from the cosmos. His broadcasts for the BBC in 1950 were just extraordinary, and brought him immediate fame as a gifted expositor. With his gritty Yorkshire manner, his ability to be picturesque using words alone, and the universe itself as his topic, he transformed the BBC's approach to academic lectures, persuading them of the benefits of a less donnish style of presentation.

His lectures for radio audiences set the prelude for a brilliant parallel career as a popular science and science fiction writer. In the former genre,

he followed his hero Eddington, soaring over the latter as a truly best-selling author. In science fiction, his first novel, *The Black Cloud*, remains his best, having now acquired cult status: in 2004, an opinion poll conducted by the British newspaper the *Guardian* to find the most accomplished science fiction writers placed Hoyle in third position!

Unfortunately, Hoyle's university career came to an undignified end in 1972 when a series of decisions by the University of Cambridge gave him the profound impression that envious colleagues had conspired behind his back to push him out. The publicity resulting from his resignation delivered a seismic shock to British astronomy, but fortunately, the professional community, by now large and diverse, quickly persuaded their political paymasters that all was well.

Fred Hoyle had a very considerable influence on my own career, although I cannot claim, unlike many astronomers of my generation, to have been attracted into the subject by his radio broadcasts. My own trajectory started in high school with evening classes, and then the opportunity to use the telescope of the Leicester Astronomical Society. As an undergraduate at the University of Oxford, I was strongly attracted to nuclear physics, where happenstance brought me into contact with Rudolph Peierls, who had taught Hoyle nuclear physics (but I did not know that at the time). Like Fred Hoyle, I chose astronomy rather than nuclear physics as a career. In 1968, the then recent discovery of pulsars became the magnet that drew me to the Cavendish Laboratory in Cambridge, where my doctoral research involved daily contact with the radio astronomer Martin Ryle, Hoyle's arch-rival. After I completed my PhD, I had the distressing experience of a very sharp disagreement with Ryle, which led to my resignation from his group. Quite quickly, Fred Hoyle threw me a lifeline by offering a temporary position in his Institute of Theoretical Astronomy. This post brought me into contact with his associates and students. A few months after Hoyle's 1972 resignation, it was my fortune to be appointed to a management position in the new Institute of Astronomy, which enabled me to refresh and expand my network of Hoyle contacts. But for Fred Hoyle's initial appointment, I would not have been able to progress to such a satisfying career at Cambridge.

In researching this biography, I often compared Hoyle to Copernicus, Newton and Einstein. These latter were achievers on a timescale that repeats only over the centuries rather than over a generation for the next decisive move forward. What is extraordinary about Fred Hoyle's science

is that his impact derives equally from instances when he was right and others when he was wrong! Generally within academia, an erroneous paper is quietly forgotten: it receives the silent treatment. Hoyle's contribution to the advancement of astronomy derived much of its impetus from the way in which his colleagues recoiled at his notions. His opponents deployed enormous resources to wrong-foot him. In the twentieth century, no other figure in astronomy had to withstand for such a long period the criticisms of both the invisible college of astronomers worldwide and the parochial college of Cambridge practitioners. Hoyle's scientific life was truly unparalleled, and unforgettable.

1

AN END AND A BEGINNING

On 19 August 1972, Fred Hoyle sat in his office at the Institute of Astronomy in Cambridge for the last time. His summer had been busy. A record number of academic visitors had come to the institute to benefit from summer conferences, collaborations, lectures and discussions. He had fretted to make sure the institute would be financed securely for the next five years. Just three weeks earlier, the Institute of Astronomy had been born through a merger of two astronomy departments, after the university had decided to join the historic Observatories established in 1823 with the pioneering Institute of Theoretical Astronomy founded by Hoyle in 1965. Hoyle had been the head of Theoretical Astronomy for seven years, but now he had a new boss, because the university had not chosen him as the director of the combined institute.

On a sultry afternoon with a threat of thunder in the air, staff members who were in the old Observatories, including myself, made the short walk along the path through the parklike grounds to the building that had been the Institute of Theoretical Astronomy – IoTA for short – to take their afternoon tea in the library. This wonderful Cambridge tradition gave the researchers and their students an opportunity to exchange ideas, and maybe wish a departing visitor a safe trip back to California or India. But this afternoon, Hoyle would not be joining his colleagues for tea. He had spent the past two weeks clearing his vast office of personal documents, books, and drafts of scientific papers, the result of thirty-six years of scientific work, much of it carried out in Cambridge.

Affairs of state had eaten into a lot of his time for the past year, and we had seldom seen him in the institute. He juggled the duties of being both vice president of the Royal Society and president of the Royal Astronomical Society. At the February meeting of the Royal Astronomical Society he had presented the Gold Medals. One of them went to Fritz Zwicky, of the California Institute of Technology, where Hoyle himself had made astounding breakthroughs some twenty years earlier. After the presentations of the medals, Hoyle had given a lengthy lecture setting out his ideas on the origin of Earth and evolution of life on it. This was not a mere summary of accepted theory, but his own views on what might have happened. On the research front he had worked on new theories of gravity and had published two demanding technical papers. He was still as productive as ever, working up novel ideas into papers, one after another.

Whereas most mature scientists would be content with two or three papers a year, Hoyle was still writing books at a furious pace. There had been two this year. One reviewed the scientific case for interpreting Stonehenge as an astronomical observatory and eclipse predictor, ideas that had brought him into sharp disagreement with archaeologists.[1] The following year, 1973, would be the 500th anniversary of the birth of Nicolaus Copernicus, who had taken the decisive step of abandoning the Earth-centred universe of ancient Greek philosophy. Copernicus had published a new, but flawed, theory of the universe with the Sun rather than Earth at the centre of the solar system. Hoyle was hard at work for his London publisher on a book celebrating the achievements of Copernicus as one of the founders of modern science.[2]

His year started in turmoil and conflict about how the government's funding for scientific research should be handled. Two national committees of scientific gurus had reported to the government that a greater proportion of the money should go to projects of direct interest to the taxpayer and that the cash should be channelled through ministries other than the Department of Education. Hoyle smelled a rat. If the proposals were accepted, then future funding would be in the hands of politicized decision makers rather than the scientists and professionals in education. Hoyle set about vigorously lobbying the scientific community to resist 'the setting up of more bureaucratic machines'.[3]

The following month, February, Fred had flown to Australia to discuss plans for the new Anglo-Australian Telescope. He travelled with a colleague who was on the inside track of political machinations at Cambridge.

This colleague had dropped a bombshell into the conversation: the university appeared to be considering the appointment of someone other than Fred as the director of the combined Institute of Astronomy. The news was a heavy blow – so heavy that, during a stopover in Los Angeles, Hoyle dashed off a letter of resignation to the vice-chancellor. Hoyle was already feeling completely through with Cambridge by this time because of its dithering and (as he saw it) inept approach to making senior appointments.

Now, on his last day, he felt deeply that his beloved institute had been stripped of its international character. In 1961, he had developed the idea of an institute devoted solely to the theoretical side of astronomy. In only a few days' time, his world-class theory team would be united with astronomers who built instruments and looked through telescopes. He supported both communities but could not come to terms with the university's decision to disregard him when it came to appointing a director. He was certain he had made the correct decision.

For decades, Hoyle had been the best-known astrophysicist in Britain. His output of technical papers was prodigious, but he never confined himself to the ivory towers of academia. A gifted popularizer, he could make the most profound intellectual puzzles into entertaining radio talks and lucid television programmes. Fred Hoyle's broadcasts and books influenced many of us who were drawn into astronomy. Most years, he wrote a book, sometimes two. The sweep of his accomplishments as a writer covered a spectrum from popular books to technical monographs. Imaginative ideas that were too speculative for journal papers and serious books were cleverly developed to be aired in the guise of science fiction.

Despite his fame and standing, matters in Cambridge had somehow unravelled in the past year so that, as Hoyle put it, 'Now I really did want to be done with it.'[4]

Even when the tea drinkers had drifted back to their offices, Hoyle still felt unable to make a break for it, not wishing to endure the embarrassment of further handshakes, eye contact or best wishes. By early evening the institute building was finally empty. The time to depart had come. He would head straight for the main door and be done with the institute forever. He took a last look round the office and, as an afterthought, picked up the inky blotter on the desk as a memento. He seldom used ballpoint pens, always choosing to write confidently with a fountain pen and rarely revising manuscript drafts. Just as he left the office, which was at the end of a long corridor and some distance from the front door, he changed his mind about

bolting for the exit. Instead, he took a nostalgic tour of the building, his pride and joy. Though founded by him, funded by his pleas for cash and populated by his handpicked team of research astronomers, it welcomed his presence no longer.

Ray Lyttleton's office was nearby. Ray was Hoyle's earliest collaborator and together they had done important work on the origin of the solar system. In a long career, Lyttleton had made the strategic error of continuing to work in the same area, defending his early papers from attack. This approach was very different from Hoyle's, which was to keep moving into new areas before someone else came up with a better idea. I remember Lyttleton in those days as a sad figure, still the holder of a prestigious professorship but not a scientist anyone listened to or read any more. Taking his last look, Hoyle glimpsed Lyttleton's work on a spoof paper, trying to prove mathematically that it should be impossible to ride a bicycle.

Cyril Hazard's office was next. Cyril was making a huge effort to identify very distant objects now known as quasars. Most astronomers believed quasars were at immense distances from our galaxy, but Hoyle thought they could have been ejected from nearby galaxies. Hazard's objective was to get accurate distance measurements (a part of the project on which I myself collaborated with Hazard) and to nail the problem one way or the other. Hoyle looked at Cyril's office. It was a wasteland of scientific papers, piled so high and loosely against the window as to form a miniature landslide that extended halfway to the door. His desk was submerged under a mountain of photographs of candidate galaxies and quasars that Hazard worked on with collaborators in the United States. The blackboard was a mass of random prompts: names, ideas, galaxies to investigate. Here was a great friend and collaborator who, as a result of Hoyle's resignation, now faced an uncertain future without a job.

Further along the corridor lay the study of Sverre Aarseth, who had joined Hoyle years earlier as a graduate student and had then been appointed to the research staff in the foundation year. He and Fred had a strong interest in chess and were intently following the Spassky–Fischer world championship in Reykjavik. On the last day of the Institute of Theoretical Astronomy, Aarseth had organized a boat trip up the River Cam to the cathedral city of Ely. At the end of the trip, when IoTA was no more, Aarseth presented the former director with the official visitors book, which had been kept since 1965. Such a volume normally would have been regarded as part of the university archives, but Aarseth knew it would give

Fred great pleasure to have this personal reminder of all the visitors he had attracted.

Hoyle walked past the open-plan library, always the first place in Cambridge to receive from the United States the world's premier research publication for astrophysics, the *Astrophysical Journal*. Only the institute had an airmail subscription. On one table lay a large electronic calculator, purchased at colossal expense in 1968, with a display that used extremely complex neon lights to show each number. The airmailed journal and the huge calculator kept Hoyle's theorists a step ahead of the other astronomers in Cambridge.

In the lecture room, there was a wide expanse of blackboards, made from state-of-the-art ground glass and amply supplied with no-dust chalk. During the construction of the institute, Hoyle had squeezed the budget to afford blackboards of the highest quality because advances in theory require countless hours of argument at the blackboard. Now he looked at the jumble of words, mathematical symbols and general squiggles. These were the remnants from the last seminar to take place under his leadership. He could make out some patterns of thought, but others he did not recognize: even his towering intellect could not comprehend all the advances of modern astronomy.

Now he turned and swung the big heavy door to the outside world. It shut slowly behind him as he set off on the short walk home. To his right was a pasture where three horses grazed contentedly, oblivious to any cosmology more complex than a flat field of grass. To his left was a building housing the IBM 360/44 computer that Hoyle had purchased as bait to lure summer visitors from the United States, who used it to model the evolution of stars. Ahead, he could see the new buildings of the department of physics, which had recently moved out of central Cambridge. A turn to the left, and he was walking past the entrance road to the Observatories.

I have made this walk countless times. Today the William (Bill) H. Gates Building for Computer Science blocks the view to the department of physics, but the horse pasture is still there. Hoyle was retracing the footsteps of great astronomers who had worked at the Observatories. One of them was Arthur Eddington, an astronomer Hoyle had always particularly admired. Eddington had been one of Hoyle's predecessors as the Plumian Professor of Astronomy at Cambridge. Back in 1919, he had confirmed an important prediction of Einstein's general theory of relativity: the bending of the path of starlight by the gravity of the Sun. In the 1920s, Eddington's