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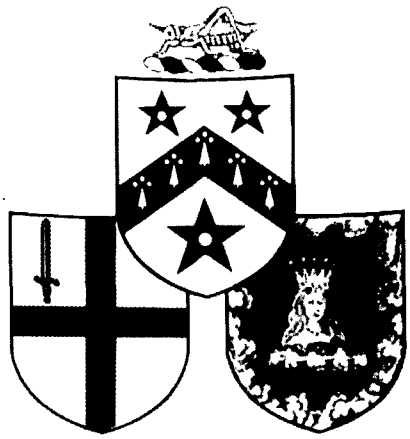

THE SKY'S THE LIMIT!

A Lecture by

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GRESHAM COLLEGE

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- to foster academic consideration of contemporary problems;

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THE SKY'S THE LIMIT!

Professor Heather Couper

Why do astronomers do astronomy? A lot of people (especially cynical journalists) ask me this question. It's often assumed that astronomy - at best - is the useless pursuit of measuring the positions of stars in the sky, or - at worst - is something to do with being engaged in a secret follow-up to President Reagan's Star Wars military programme. Whatever, astronomy is believed to be other-worldly, irrelevant, a waste of money, and something that is only studied by old men with long white beards.

Wrong. Astronomy is a subject at the cutting edge of science - a subject so complex that it's often best tackled by the youngest, brightest and most agile brains around. One reason for this is that it covers all the sciences, from maths through physics and information technology, to chemistry and even biology. It's fast-moving - just think of the plethora of discoveries in astronomy that have been announced in the last couple of years.

And it's highly relevant. Put it like this: on Earth, we try to understand the basic nature of matter by putting atomic particles through their paces in particle accelerators. But the energies we achieve are nothing like those we can reach in space - such as in the vicinity of a black hole, or an exploding star. In a nutshell, astronomy is the most fundamental science of all: the study of how matter behaves in that laboratory of extremes we call the Universe.

There's even more to it than that. Astronomy touches on some of the deepest questions we ask. How did the Universe begin - and how will it end? Is there an edge to space? How far are the stars? Is there life out there?

This heady combination of cutting-edge science and curiosity combine to make astronomy one of the most fascinating subjects of all. But it is still an area of complete mystery for most people. For instance, how do astronomers go about their tasks? Who goes into astronomy? And what can the person who hasn't studied the subject at university for six years hope to get out of it?

This talk splits into three unequal parts. First, the hows and whys of astronomy. Then a human look at astronomy - how a management trainee working for Top Shop gave it all up for the sake of the stars. Finally, there's astronomy for everyone - how anyone can be an astronomer.

Hows and Whys

Everyone knows that an astronomer studies the stars through a telescope. But they're not sure why, or how. Some have a vision of an ancient gentleman, huddled up against the cold, peering myopically through a battered brass tube. But those days thankfully vanished a century ago.

Today's astronomers certainly use telescopes. But they would never dream of looking through them - because there is nowhere to put your eye. Modern telescopes are giant buckets for collecting light - the more light you capture, the more detail you see, and the fainter you can go. These huge flux-buckets use huge curved mirrors, like shaving mirrors, to gather and focus light. The biggest telescope in the world - the Keck Telescope, on Mauna Kea, Hawaii - has a

mirror 10 metres (over 30 ft) across. The light these giant mirrors collect is focused onto a whole battery of sensitive electronic instruments which dissect, scan, analyse and generally manipulate it. After a typical two- or three-day observing run, an astronomer will return from the telescope to his or her own institution, often on the other side of the world. For the next year, or more, the task will be to bring powerful computer-muscle to the data, and come up with an explanation of what the observations mean.

Then there are telescopes and telescopes. The familiar 'dome on a mountain' is an optical telescrope - but light is only one 'window' through which modern astronomers observe the Universe. Radio waves from objects in space also penetrate the atmosphere, and can be detected by radio telescopes - like huge satellite TV dishes. Other radiations similar to radio waves and light are also emitted by celestial bodies, but we didn't know about them until recently because they are blocked by the atmosphere. But satellites in orbit can easily pick them up, and now we have the disciplines of gamma-ray, X-ray, ultraviolet and infrared astronomy. Observing in different wavelength windows like this reveals much more about how celestial objects emit energy, and tells a much more complete story.

Why study the stars? Because, as I said at the beginning of this talk, astronomy gives you a much wider picture of how matter behaves than we can ever obtain on Earth. For instance, we have never properly succeeded in initiating 'nuclear fusion' - squeezing atoms together to obtain energy. But the stars have no such problem. Deep in their cores, they are natural nuclear fusion reactors. That's why stars - like our local star, the Sun - give out so much light and heat. But stars are more than just cosmic nuclear reactors. They have life cycles like us, although very much longer. All stars are born, live their lives, and die - and if we can understand why, we come closer to understanding our own origins.

Then there are objects out there - black holes, neutron stars, supernovae - which give out such phenomenal quantities of energy that no particle accelerator on Earth could ever come close. By studying these violent cosmic beasts, we can gain access to conditions that would otherwise be out of our grasp.

At the other extreme, we are now using robot spaceprobes to explore nearby planets neighbour-worlds that bear marked similarities to the Earth. But as far as we know, none of them has life. Astronomers are trying to understand why Earth is just right for life - and looking for clues as to what went wrong on the other planets to help us manage our own earthly environment in the long-term.

Astronomers also study the 'geography' of the Universe. This has led to the discovery that, on its largest scales, the Universe is expanding. By putting the tape in reverse, so to speak, we can study its history. Everything points to an incredibly hot and violent birth in the 'Big Bang', some 13 billion years ago - when conditions were so extreme that only particle physics can describe them. Research into the Big Bang is one of the most exciting fields of science, where we really hit the buffers of knowledge. Keen young graduates fall over themselves to make sense of this final frontier, where multi-dimensional geometry rears its head, quantum theory breaks down, and the question arises of multiple universes appearing out of the 'cosmic foam'.

Getting into Astronomy

For me, it all started with my father's being an airline pilot. I loved planes. And as a seven-year old, I used to watch lit-up planes at night as they flew over my Ruislip bungalow, stacking

to land at Heathrow. One night, I saw something incredible. A brilliant green shooting star flashed across the rooftops. Although it was 11 pm, and I should have been in bed, I rushed into the living room to tell my parents. They were patient, but gently deprecating: "That's nice, dear. But there's no such thing as a green shooting star".

In the *Daily Express* the next day, I had my proof. 'Green shooting star seen over west London', read the (very small) headline. But it didn't matter. I'd made my discovery (although, to this day, I've no idea why my meteor was green. Was it a small lump of rock which contained copper?). From then on, I was insatiable - I wanted to know EVERYTHING about astronomy. Patrick Moore books became birthday and Christmas presents (my first was called *The Boy's Book of Astronomy*), and a couple of small telescopes followed. Every clear night, no matter how low the mercury dropped, I was out in the back garden getting to know the stars and planets. I was particularly interested in finding double stars - these are apparently single stars which, on examination through a telescope, have a companion star.

At the age of 13, I made another discovery. Boys. And clothes, make-up, rock bands, television... I'm afraid that astronomy suffered dramatically. It seemed to have no place in the modern world, and I dropped it like a hot potato. However, I managed to get 9 GCSEs, and vaguely (pushed by my highly intelligent mother) considered astronomy as a career when I was doing my A-levels in physics, maths and geography - but I didn't get very far. Instead, still lured by bright lights and glamour, I managed to land a job as a management trainee with the Top Shop fashion chain. My A-levels? Geography: grade A. Physics: grade E. I'd abandoned maths long before the exam.

Fashion retailing was nothing like as glamorous as the glossy magazines had portrayed it. It was largely slog, and I was hardly using my brain at all. As a result, I enjoyed studying one day a week at the College for the Distributive Trades in Leicester Square for my Certificate in Retail Studies. I passed the exam with flying colours. Top Shop sought to elevate me to become Assistant to the Director of Administration, which was then a very high post for a 19-year old. But it required further study, and I would often trek to my local library to get out books on modern retail practice.

One day late in 1968, when I was flicking through earnest tomes explaining how 'shrinkage' (shoplifting) was having a big impact on the retail industry, my eyes glazed over. What was I doing in retailing? It all seemed absurdly superficial. But what else could I do? Then I remembered. On the opposite side from the retail books was the astronomy section, from where I had borrowed books as a child. Hungry for real knowledge, I walked over and picked up a copy of a book called *The Universe*, by the science fiction writer Isaac Asimov.

But this wasn't science fiction - it was a history of the Universe. And it completely changed my life. Asimov, as everyone knows, wrote compellingly, and most of what he said up to about 1960 I knew about already. But I wasn't prepared for the shock that, in the six or so years I'd been away from astronomy, there had been a revolution as great as the one that had taken place when the telescope was invented. Computers, spaceprobes, electronics, satellites, daring new theoretical ideas - they had all had their part to play in the total rejuvenation of a subject. All manner of new beasts were now known to live in the cosmic menagerie: quasars, pulsars, the microwave background radiation (but black holes were still in the future).

That was it. In my closing diary notes for the year, I remember writing, Adrian Mole fashion, 'What I really want to do is to help knowledge'. I was determined to get into Astronomy

proper as soon as possible - but how? Luckily, my ever-observant mother picked up something in the local paper about the nearby West of London Astronomical Society, which I quickly joined - and discovered, through the wider astronomical grapevine, that there was a humble, temporary job up for grabs at the Cambridge Observatories. Within six months, I had given up Top Shop and had moved to a lowly bedsit in Cambridge - all for a one-year contract. My retailing colleagues thought that I must have become involved with a hippy!

My year at Cambridge was an eye-opener, to say the least. I knew about backyard stargazing, but I had no idea how professional astronomers operated. I was desperately keen to know - and my enthusiasm rubbed off on my colleagues, who were equally keen to teach me. They spent infinite time introducing me to the intricacies of computers, what observing with electronic equipment is all about, how to use the library, and they even revealed the excellence of their college wine cellars.

My job at the Observatories was pretty basic - measuring up data that had come from the Solar Observatory on Malta - and it was made clear to me that any other astronomical job would be a dead-end unless I equipped myself with some qualifications. I already had two A-levels (you already know the physics grade!), but to get into university, I desperately needed maths, too. So the Observatories kindly paid for me to study at Cambridge Tech one Monday night a week for a six-month crash course (you can say that again!) in A-level maths. I scraped through, as I had done in physics, with the lowest possible pass grade - but the University of Leicester had, for some reason, taken a shine to me, and accepted me for their astrophysics course on the basis of the A-levels I had.

University life was nothing like I had imagined. I thought it was going to be like school, but it was much more fun! I'm afraid I wasn't a model student. By then I'd met my best friend, fellow Leicester student Nigel Henbest, and for a couple of years we mis-managed the University Astronomical Society. As it became fabled for its parties, I became fabled for my lack-lustre grades in end-of-year exams. (None of the partying had any effect on Nigel, who ended up with a brilliant First without any apparent effort, and went on to study at Cambridge.)

In my third year, I knew I had to buckle down - and ended up with a creditable Upper Second. But it's one thing to get a degree; you have to prove you're a competent astronomer by next pursuing a research degree - preferably a doctorate. I had hoped to follow Nigel back to my beloved Cambridge, but there was a snag - the head of the radio astronomy department, where I had hoped to study, had just been appointed Astronomer Royal. As a result, they had more Firsts clamouring for places than they knew what to do with, and there was no room for me. It had to be my second choice - Oxford.

It was not a wise move. Although I had managed to get into the subject area of my choice (clusters of galaxies), I was lonely to begin with, and I really hadn't appreciated the nature of research. To be a good scientific researcher, you have to be obsessed with the problem you're investigating - you must live, eat and breathe it 24 hours a day. Only that way do you get a fresh approach, and many of my fellow students had no problem with it. But I'm not like that. I have a butterfly mind that darts from flower to flower all the time - from music to winetasting, from dining to exploring the English countryside, from theatre to having a bash with friends. And there was ample opportunity to do all that while I was a student at Oxford. I never got round to submitting my thesis.

The next year was a bit of a blur. After all, what do you do with your life if you're a combination of retail manager-cum-astronomer? The answer was to go and share a house with my astronomer friends in Cambridge, and claim HM Social Security. That's when friends from back in London rallied round. By chance, a number of them had gone into publishing. "Can you write?", they asked me. I remembered that I had been judged brilliant at essays when I was at school - a source of deep embarrassment, because I regarded essay-writing as something cissy (I've always been a tomboy). Soon, I found myself writing brief articles for encyclopaedias - and before we knew it, Nigel and I were working on our first book (a very simple guide to space for very young children!).

As if to prove that a training in science equips you for anything, at around that time, Nigel and I had a phonecall from our former tutor in Leicester. "How do you feel like being geophysicists for six months?" he asked. "After all, you know the physics bit, and the geo-bit is easy - the Earth is just another planet". That's how I spent the summer of 1976 working on Mount Etna, installing tilt-gauges that would predict when the volcano was due to erupt (they got buried under lava before we could get back to measure them!). During my time back in Leicester, I also found openings in the extramural department to give adult education classes - and finally realised that I'd found my métier in communicating to an audience, rather than in hiding away writing.

Nigel and I now had a ground plan. As far as we could see, very few people at that time were communicating the excitement that was going on in professional science. We resolved to move down to London (this was before the electronic revolution in communications which allows you to live anywhere) to pursue our goal. The scheme was that I'd do the broadcasting; Nigel the writing. The first of us to get a job in London would trigger the move.

It turned out to be me, when I landed the post of Lecturer at the Greenwich Planetarium in 1978. My career got off to a good start: as well as the work at Greenwich, there were appearances with Patrick Moore on his Sky at Night TV programme, more books, and some radio broadcasts. But alas - The National Maritime Museum's PR Department had an attitude in those days that broadcasting was not a good thing. I had to take special leave to do it (and then only with permission in triplicate from my boss, the Head of PR and the Museum Director himself!). So the opportunities were limited.

Meanwhile, Nigel - as a freelance - was surging ahead. As Astronomy Consultant to *New Scientist* magazine, he had attracted a lot of attention from other organisations. At one stage, he had a consultancy for every day of the week, and his clients ranged from the Royal Greenwich Observatory to the Science Photo Library. Meanwhile, most of my work consisted of giving talks to ten-year olds.

Five years after joining the Planetarium, I took a deep breath and left to go freelance. I worried that there might not be room for another astronomy communicator (there was, by now, some stiff competition around). But Nigel and the others welcomed me warmly, and soon I was getting a steady stream of work.

The big change happened just over a year after going freelance. Patrick Moore was then President of the British Astronomical Association - a post the incumbent holds for two years - and was coming up to 'retirement'. When he had taken the mantle on, he'd told me he would only do it on the condition that I followed him. I wasn't sure if he'd remember that condition, but he certainly did. One day, he took me aside and asked: "Well, Heather, how do you feel

about the Presidency?" As it was also a very active time in the American Presidential campaign, I was very confused!

So on Halloween 1984, I became President of the British Astronomical Association. In nearly 100 years of the Association's history, I was the second-youngest incumbent and the first woman President. This latter fact made the media go bonkers (although to be fair, Nigel - as the then BAA PRO - had sent out a press release headed 'Heavenly Heather takes over from Patrick Moore'). I ended up on every programme from Wogan to Woman's Hour, and the press literally beat a path to my door (one journalist, having made an uninvited journey from Fleet Street to my hard-to-find cottage in Greenwich, was flabbergasted to miss me because I'd gone out to lunch!).

At first, the media attention annoyed me. I've never been a feminist, and it didn't excite me that I was the BAA's first woman President - the Universe is no respecter of gender, and I didn't see why anyone else should be. But my colleagues told me that I was missing the point. I was being offered a platform - never mind if it was for all the wrong reasons. Why not use it as a soapbox from which to promote awareness of science?

I certainly got every opportunity, for this was the era of Halley's Comet - and the media were doing their best to incite Halleymania. I think many astronomers will remember telling people not to get too excited, because Halley was going to be a damp squib on this occasion - only to be blamed by the media after the event for not giving due warning!

But it was fun. My highlights of the Halley period included naming a locomotive ('Halley's Comet') at Manchester's Piccadilly railway station, and an unforgettable flight on Concorde to New Zealand. My job as 'astronomer in charge' involved pointing out the comet over the Indian Ocean, but alas - because of the way the date had worked out, Halley was right against the Milky Way! All we could see was a fuzzy blob against a fuzzy blur through the thick glass of Concorde's tiny windows. But when we landed in New Zealand, it was a different story. The comet had moved out of the Milky Way by then, and was a stunning sight in the southern sky.

Halley apart, I was often wheeled onto television to comment on matters astronomical. On one occasion, I got a little cheesed off with Peter Snow on Newsnight sending up black holes as something out of pure fiction. I picked up my water glass and pointed inside. "You know, Peter, if this were a black hole and you were to fall in head-first - like this - the gravity would stretch you into a long, thin tube. In other words, you'd be spaghettified". My temerity at taking on Peter Snow so impressed a leading firm of London agents that they signed me up immediately - and I was soon on my way to making my Channel 4 TV series 'The Planets'. I began to realise that the media was something I had been born for.

Three years later, I was hoping to follow it up with 'The Stars'. By then, I was working well and truly in the thick of the media, and knew which people I'd like to have on board. There was Nigel, of course - and a director called Stuart Carter who was a pal, but whom I'd never actually worked with.

Stuart was busy and played hard-to-get, which meant that filming was put on hold for at least six months. In a production, the director is the most important cog in the wheel: his or her creative overview is what gives the programme its 'look'. So we bided our time.

In the end, the round-the-world shoot, which took in Australia, Hawaii and California, was hugely successful - and so were the programmes. Stuart, Nigel and I met up for a celebratory drink and to discuss future projects. "What do you guys reckon on doing for the rest of your lives?", Stuart asked us. "Making great television programmes like 'The Stars'", we replied. And thus Pioneer Productions - our own independent TV production company - was born.

After a shaky start (there are over 1,000 other independents out there to compete with!), Pioneer began to make it big in America - especially on the Discovery Channel, which specialises in showing factual programmes like the ones we make. At the same time, we started to pick up prizes for programmes shown over here, too - 'ET - please phone Earth' and 'Electric Skies' (about lightning) have both won the Gold Medal at the New York Film and TV Awards.

As we became more successful, we grew - and moved to a suite of offices at Pinewood Studios. But our roles were changing, too. Although we were still creating the ideas for programmes, we would hire talented directors and crew to make them. Even though we did have final editorial control, we were working more like managers than as programme makers who got their hands dirty. That's why we were so delighted when Gresham College put up the money for us to make a commercial video called 'Heather Couper's Guide to the Universe' (it's actually a simple introduction to stargazing). Stuart directed, Nigel consulted, and I wrote and presented - just like the old days!

Now, Pioneer ranks amongst the top 40 production companies in the UK. Our programme output covers the whole factual arena, with series like 'Body Atlas', 'Wonders of Weather', 'Extreme Machines' and 'Violent Earth'. We're in discussion with the newly-formed Channel 5 about a drama, and with agents in Hollywood about a screenplay. And we're constantly on the lookout for new business opportunities to expand Pioneer's core activities.

Would I ever go back to pure astronomy? No. With my butterfly mind, I have always been a communicator rather than a researcher - and working in the media means that I have the ultimate freedom to flit wherever something interests me. For instance, I would love to make more programmes about some of my other passions, like classical music, the English countryside, food and wine. And because I get invited to participate in all manner of things, my life keeps on going in unexpected directions - and into fascinating new areas - that I could never have predicted. Like the honour of being appointed Gresham Professor of Astronomy, and discovering the unique and vitally important role that the College plays in intellectual life today - it is truly independent. Then there's the Millennium Commission. My membership of this nine-strong, fiercely individual and outspoken committee has been the equivalent of doing a degree in politics, property law, finance and diplomacy all combined!

The Sky's the Limit

But I still derive great happiness of going out on the back terrace of my Chilterns farmhouse on dark, clear evenings and gazing at the stars. I know their names; they're my friends. The last thing on my mind is that they're huge nuclear reactors hundreds of light years away. The sight of the stars on a clear night is like looking at a beautiful landscape.

And that, to me, is the real glory of astronomy - you can appreciate it at any level. You might be content knowing a few of the star-patterns, and watching the occasional shooting star. You

can become an amateur astronomer, and take beautiful photographs of stars and glowing gas clouds through your telescope. Or you could go professional, and spend your life researching a topic which, to most of us, might seem rather abstruse - how does "unstably-stratified magnetic fields in late-type stars" grab you?

Whatever you choose, it doesn't matter - we all have an astronomer inside us somewhere trying to get out. The wonderful thing is that there are no boundaries as to where your interest in the heavens might take you. As they say, the sky's the limit!

The Sky's the Limit: where to turn for more information

Heather Couper's Guide to the Universe is the 1-hour video made possible with funding from Gresham College, and produced by Pioneer Productions. It costs £9.99 and is available from HMV, Virgin stores, and The Nature Company. In case of difficulty, write to IMC Video, 23a Cornhill, Marketplace, Banbury, Oxon OX16 8NG

If you're really keen on astronomy, it's well worth joining an astronomical society. You can attend meetings and courses, as well as getting guidance on books, software and telescopes. The best society for beginners in the UK is the Society for Popular Astronomy, 36 Fairway, Keyworth, Nottingham NG12 5DU

For guidance on telescopes (and all forms of astronomical instrumentation), you can't do better than to go along to Broadhurst Clarkson & Fuller Ltd. Telescope House, 63 Farringdon Road, London EC1M 3JB (0171 405 2156)