SECTION EIGHT

Final Address

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The Role of Astronomy in Education and 'Public Understanding'

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Although it comes at the end of the programme, this contribution is in no sense a 'summary' of the meeting. It addresses some issues that were covered by earlier speakers, but is written from the individual perspective as a research astronomer working in the UK.

1. Astronomy and Young People

A few comments first on education in schools – this is a special worry here in the UK, where our international rankings are disappointing. An appreciation of science is vital not just for tomorrow's scientist and engineers, but for everyone who will live and work in a world even more underpinned by technology – and even more vulnerable to its failures and misapplications – than the present one. Even more important, the option of higher education in science and technology should not be foreclosed to them. There is widespread concern particularly about the 16-18 age group. Many of us put strong emphasis on broadening the curriculum for this group, which currently enforces unduly early specialisation here in England. Young people opting for humanities should not drop all science when they are 16. (I have carefully said 'England' rather than 'the UK' because the curriculum is already broader in Scotland. Scottish education has its admirers here, but few in Scotland advocate a switch to the English system!)

It is crucial that enough of the brightest young people go on to acquire some professional expertise in science and technology. They will not do so unless , when making the key decisions at age 16 or 18, they perceive a range of appealing opportunities. They will be discouraged if the courses do not inspire them. They will be discouraged if scientists seem valued less than accountants. And they need to feel that science is humanly relevant – that it meets their ethical concerns. (A separate issue is the depressingly low proportion of girls among those who opt for physical sciences – the proportion of women in science and technology will always remain low unless the trends and choices made by 16 year olds can be changed.)

Astronomy has a specially valuable role to play. It attracts wide public interest. It has a positive and non-threatening public image. In this latter respect it has the edge over other high-profile sciences such as genetics, and nuclear physics. It is also inspiring to bright students. An interesting survey was recently carried out carried out among those in their first term at UK universities who had chosen to study physics. They were asked what had influenced their choice. Astronomy and space ranked high. (It was also clear that many had been enthused by particular teachers; text books ranked low, but 'popular' books and magazines were major influences.)

It is right that astronomy should be part of the formal school curriculum. But young people are a receptive and important target for informal initiatives, of the kind addressed at this conference. There are many innovative schemes for bringing individual research scientists in contact with schools. There is growing scope here: telecommunications allow remote access to large facilities, so that individuals – amateurs at home, as well as young people at school – can participate in scientific discovery.

Virtual reality offers new opportunities for science centres, etc. This, however, raises

the important issue of whether 'virtual reality' is a supplement and enhancement to what we have already, or whether it may be a counter-educational substitute for traditional 'real' (hands on) reality. Scientists already spend much of their time in cyberspace – almost instant contact with colleagues and collaborators around the world. This affects communication and journal publication (though it has not made conferences obsolete). But it also affects how we do science, what we value. At its worst, the information highway could just smother us in shoddy work. At its best, it can offer marvellous opportunities, especially (if they can surmount the threshold of resources needed for access) to developing countries.

2. Public Perceptions of Science Generally

I will come back to say a bit about college education, but I would like to say something about popular science and the media generally. I have been influenced by recent experience as President of the British Association for the Advancement of Science: this is an organisation, dating from 1830, whose mission is to promote understanding of (and debate about) science, engineering and technology.

In the British Association's Victorian heyday, the national scientific enterprise was minuscule by today's standards. But the commitment to public understanding was not. The marvellous national and civic museums – cathedrals of discovery and invention – consumed large resources by the standards of that time. Our forebears believed that science, engineering and technology deserve wider appreciation, that science is part of our culture, and that how it is applied should concern us all.

Science and engineering had a high profile. Most people have heard of the great 19th century engineers – Brunel, Telford and so forth. It is actually harder to name living engineers – even though their marvels surpass those of earlier centuries.

And it was not just the practical men – the 'wealth creators '– who earned public acclaim. Think of Darwin: his insights had no practical payoff, but he was a revered figure because he changed the way humans see their place in nature. There was also wide interest in exploration of remote parts of the Earth.

Astronomy and cosmology maybe play the same role in contemporary culture as Darwinism and terrestrial exploration did a hundred years ago. We can now probe our cosmic environment and origins; our explorations of the cosmos with telescopes and spaceprobes can be vicariously shared by a wide public. Just as Darwin attracted interest so now do the discoveries of astronomers – setting our entire Earth origin in a cosmic context.

Manned space-flight is, of course, the highest profile and most expensive aspect of our field. The Apollo moon-landing programme was a spin-of, and indeed an inspiring one, from the superpower rivalry of the cold war era. But NASA's current space station seems neither inspiring nor a step towards any worthwhile longer-range goal. There is one striking feature of people's perception of the Apollo programme. Along with everyone else who has now reached middle age, I grew up thinking of 'men on the moon' as a futuristic concept. It became reality in 1969. Even the last lunar landing was 1972. Nobody much under 35 can remember it. To all young people today – to my present students – it is a remote historical episode. They know the Americans landed men on the Moon, just as they know the Egyptians built the pyramids. But the national motivations seem almost as bizarre in the one case as in the other. And the recent film of Apollo 13 – the mission that nearly met disaster – seems to them as dated, in technology and in values, as a traditional 'Western'.

What is the general state of public attitudes to science, engineering and technology? We have all seen quizzes that check what science people know; these are sometimes

inflicted, to their embarrassment, on politicians and other dignitaries It is sad if such people's astronomical views are pre-Copernican – or if they cannot tell a proton from a protein. But they can (partially) excuse themselves by claiming that the facts in themselves are not the essence. What matters for everyone is having a rough 'intellectual map' : so that we can appreciate our natural environment; so that the artifacts that surround us do not seem mysterious; and so that we can participate in shaping how technologies are developed and applied.

Everyone needs a basis for assessing when scientific claims are credible and when they are not. Noisy controversy does not always signify evenly-balanced arguments; but most issues that rightly concern us involve genuine scientific uncertainties, and major tradeoffs. The ethical and social implications of (for instance) environmental degradation can and should be widely appreciated and discussed, even by people who do not understand (and may not be specially interested in) the science *per se.* (The same is true even more of biomedical issues.)

3. The Media

Here in Britain there is a long tradition of science popularisation. In astronomy it goes back to Eddington and Jeans, and continues, through Fred Hoyle and others, to Stephen Hawking and Patrick Moore. There are also equally impressive figures in other fields.

There is also a strong tradition of science journalism. But there is an impediment – these dedicated journalists are up against the problem that few in editorial positions have any real background in science. The editors of even the 'highbrow' press feel they cannot assume that their readers possess the level of scientific knowledge that we might hope for in a fourth-former, whereas the same journals would not 'talk down' to its readers on an economic topic or on the arts pages: economic articles on the money supply are quite arcane; the music critic would be thought to be insulting his readers if he defined a concerto or a modulation. About half of the readers of the quality press have some scientific education, or are engaged in work with a technical dimension It is those who control the media (and those in politics) who are overwhelmingly lacking in such basic knowledge.

(There is perhaps an interesting lesson to be learnt from the "computer pages' of many newspapers, whose success may have caught editors by surprise, just as the enthusiasm for home computing has indicated the enthusiasm and talent of young people untapped by formal education).

There has in this country been growing 'official' encouragement for Public Understanding of Science – from government bodies, scientific and professional societies, etc. Promotion of 'public understanding' is in the formal mission statements of the research councils. There are even small amounts of money to encourage initiatives of this kind. The Particle Physics and Astronomy Research Council, the body that funds astronomy and particle physics, takes this issue particularly seriously, and encourages all astronomers and particle physicists to use every opportunity to disseminate their work broadly. This research council has a special obligation, because its research, though expensive, has less short-term 'spin off' and relevance than some other branches of science; but it also has a special opportunity, because of the public interest in astronomy and space. (We try to cover particle physics, but that offers a good deal more of a challenge than astronomy.)

Public Understanding of Science, as a phrase, is slightly unfortunate or at least sub-optimal. Not only does it have an ugly acronym, but it falsely implies a demarcation between science and public – between a priesthood and an unwashed populace.

The adult 'public' is very heterogeneous. All of us here are part of it. Professional

scientists are depressingly 'lay' outside their specialisms – we all depend on 'popular' presentations for biomedical topics. Likewise, many of the 'consumers' of popular astronomy have some scientific and technical expertise in other areas.

Broadcasts or newspaper articles about astronomy deepen my respect for journalists who successfully cover all the sciences, working to tight deadlines. I know from experience – and probably most people here know – how hard it is to explain, non-technically, even something in one's specialist field.

Science generally only earns a newspaper headline, or a place on the TV bulletins, as background rather than as a story in its own right. Indeed, coverage restricted to 'newsworthy' items – newly-announced results that carry a crisp and easily summarisable message – cannot avoid distorting how science develops. Scientists cannot reasonably complain about this any more than novelists or composers would complain that their new works do not make the news bulletins. The place of science is in features, documentaries, etc, rather than news. (News coverage of astronomy and other sciences is of course further distorted because some institutions – NASA, for instance – are specially effective in relating to the press. Unfortunately the scientists themselves sometimes 'hype up' their own contributions – science reporters now have to be as sceptical of some scientific claims as they routinely are of politicians'.)

A 'Daily Telegraph' poll last year asked people on what topics they'd like to see more newspaper coverage. Top choice was 'medicine'; 'science and invention' tied with 'crime' for second place.

We are often told that science has to be made relevant to everyday life. That is true, but only up to a point. It is often the utterly 'irrelevant' subjects that fascinate people most. Dinosaurs have been high in the popularity charts ever since Richard Owen discovered them in 1841. Cosmology and astronomy rank high too, of course, so does human origins. All utterly fascinating – all seemingly quite unrelated to practical issues.

As I've emphasised, I feel great admiration for 'professional communicators'. But many of us who are professional astronomers (or indeed working scientists of any kind) do spend some time as 'amateur communicators', presenting our work to general audiences. I would personally derive far less satisfaction from my work if it only interested a few other specialists. It is a challenge – just as teaching is harder at the elementary level than at the more advanced level.

Whatever the audience reaction, the experience is certainly salutary for us as speakers. It helps us to see our work in perspective. Researchers – in astronomy or in any field – do not usually shoot directly for a grand goal. Unless they are geniuses (or unless they are cranks) they focus on bite-sized problem that seem timely and tractable. That is the methodology that pays off. But it carries an occupational risk – we may forget we are wearing blinkers and that our piecemeal efforts are only worthwhile insofar as they're steps towards some fundamental question. Arno Penzias, co-discoverer with Wilson of the microwave background, plainly made a really great discovery. But he said that he did not himself appreciate its full significance until he read a 'popular' description of it in the New York Times. (We need to oversimplify, but should not be too dogmatic. Niels Bohr said that you should speak as clearly as you think, but no more so. That is a good maxim – though Bohr himself took caution to excess by mumbling inaudibly and incomprehensibly!)

One often gets asked very 'fundamental' questions: Is there life in space? Will the universe go on for ever? Why didn't the big bang happen sooner? This reminds us of our ignorance. Also, when even the specialists are at sea, there's less of a gap with general audiences.

Claims to understand anything about the early universe might seem presumptuous.

But cosmology is actually one of the more tractable sciences. Inside a star (and in the early universe) conditions are so extreme that everything is broken down into its atomic constituents, and governed by simple laws. It is complexity that makes things hard to understand, not size. Understanding a frog is a far more daunting intellectual challenge than a star or the early universe. The atoms that made the young Earth are stardust – to have understood this is a triumph of 20th century science. But elucidating how those atoms combined, via Darwinian selection, into progressively more intricate forms, and eventually into creatures that could ponder their origin, is an unending quest that has barely begun. This perspective should caution us against scientific triumphalism – against exaggerating how completely we will ever understand anything really complex.

Incidentally, I think it is crucial that expositions of cosmology, and indeed of any 'frontier' science, should avoid conflating things that are fairly well understood (like, for instance, the broad evolution of stars, and the Hubble expansion) with those that are not (like the physics of the ultra-early universe). Otherwise, credulous readers will accept flakey ideas too readily; those who are more sceptical may, on the other hand, fail to appreciate that at least some parts of astronomy now rest on quite secure foundations.

As well as cosmology, there is also interest in more 'accessible' astronomical topics. *There will, for instance, be many 'outreach' events this Autumn linked to the 150th* anniversary of the discovery of Neptune. Britain's celebrations will be somewhat ambivalent. The story is well known of how John Couch Adams, then a Cambridge student, predicted that a new planet should exist, but parallel calculations were done by Le Vernier, and the planet was discovered in Berlin. Adams failed to activate the interest of either the then Astronomer Royal, Airy, or the then professor at Cambridge, Challis. We still have in Cambridge a 12 inch telescope, which I describe to visitors as the telescope that failed to discover Neptune.

4. Astronomy at College Level

This conference has covered many aspects of college-level education in astronomy. Introductory courses of the kind normally known in the US as 'astronomy 100' have a great value not only for their intrinsic content, but because they convey the flavour of frontier research at an elementary level. Here we have an advantage over particle physics, chemistry, or molecular biology. These courses have spawned many excellent textbooks. In the UK, there is not the same scope for these broad elementary courses because university degrees are more specialised. Those specialising in the humanities take no science courses – indeed, as I've mentioned already, they may have had none since the age of 16.

There has, however, been a growth, in the UK, of astronomy teaching at undergraduate level in conjunction with physics. Many universities (here at UCL was among the first) have joint physics/astronomy honours degrees. Astronomy offers scope to 'enrich' the physics curriculum, and its inclusion has benefited enrolments in physics departments.

5. A Sociological Note

We also, I believe, have a mission towards our academic colleagues in other fields (particularly in social sciences) – to convey the way we perceive the nature of the scientific enterprise.

The way we approach science, what problems strike us as interesting, what styles of explanation are culturally appealing, and (more mundanely) what fields attract funding, plainly depend on a range of political, sociological and psychological factors. Some

projects, especially big international ones, are a byproduct of activities driven by other imperatives. Space science is a byproduct of the superpower rivalry and rides along on a large application-led programme. Supercomputers have transformed much of our subject, etc.

It is important, as well as enlightening, to appreciate how pervasive these social and political factors are. Scientists are a fascinating topic for anthropological study. But for us 'in the zoo' science nonetheless moves towards a culture-independent outcome; it is, albeit fitfully, advancing.

We have not altogether succeeded – as Gerald Holton in the US has reminded us in his eloquent writings – in asserting and clarifying the role of science among other intellectuals.

In his book 'Dreams of a Final Theory', Steven Weinberg gives an apt metaphor: "A party of mountain climbers may argue over the best path to the peak, and these arguments may be conditioned by the history and social structure of the expedition, but in the end either they find a good path to the summit or they do not, and when they get there they know it."

Perhaps I might venture another analogy. It is fascinating to study how the development of music — for instance, the emphasis on operatic versus liturgical music; the increase in the scale of orchestral compositions that stemmed from the transition from private patronage to public concerts, etc – was moulded by social and economic factors. But this is in a sense peripheral to the essence of the music itself.

6. Conclusion

In conclusion, astronomy is a fundamental science; it is also the grandest of the environmental sciences. It has – especially during its current phase of unprecedented scope and progress – a key role to play in education at all levels, and in public understanding. We will surely all leave this meeting fully mindful of (in the previous speaker's words) the 'excitement of understanding'; and with renewed enthusiasm to spread this understanding still more widely.