GRESHAM COLLEGE

Gresham Special Lecture

Popular and Unpopular Science

delivered by

Professor Sir George Porter
President of the Royal Society

at the Bishopsgate Institute

7 July 1987

POPULAR AND UNPOPULAR SCIENCE

Science affects all our lives, but the public understanding of science is very poor. Worse still, many fear science and some oppose it. The history of, and reasons for, these attitudes are considered.

POPULAR AND UNPOPULAR SCIENCE

It is a great honour to be invited to give this special Gresham Lecture, though somewhat daunting having just heard that list of some of my distinguished predecessors who have presented it in the past. I welcome the invitation particularly as President of the Royal Society, because the Royal Society owed a great deal to Gresham College in its formative years.

Gresham College itself was founded in 1597, with the object of fulfilling a dream of Sir Thomas Gresham of a permanent academic base in the City of London. When Cambridge heard of this scheme and the large endowment that went with it, they tried to persuade him, as a Cambridge man, to divert it to Cambridge, but he turned a deaf ear to that. After his widow died, the house that was to become the College passed to the City Corporation and the Mercers' Company. Seven Gresham Professors were appointed and even after the College itself disappeared, the Gresham Professors continued to be appointed and to deliver public lectures in the City.

On the other hand the Royal Society began, as good things often do, in a very small way, informally with meetings, about 1645, of a few enquirers who had been inspired by the new experimental philosophy of Francis Bacon. Their first few meetings were in taverns around here, the Mitre in Wood Street, The Bull's Head in Cheapside, but very soon afterwards at Gresham College nearby in Bishopsgate. They usually met after one of the Gresham Professor's lectures, often in his rooms, because the Professors as long as they remained bachelors, were entitled to have rooms in the College. During the Civil War, activities were divided between London and Oxford, but immediately after the Restoration, in 1660, the Society was founded, and shortly afterwards received its charter from Charles II and adopted the title of 'The Royal Society of London for Improving Natural Knowledge'. There were some very very distinguished names associated with the Society in the early days, Robert Boyle, Christopher Wren, who was a President; (Really, Christopher Wren was more distinguished as a mathematician and astronomer, than as an architect, not many people know that); Robert Hooke, the diarist John Evelyn, Samuel Pepys (also a President); it was a very broad-based society, not of professional scientists, because there were no professional scientists. Everybody was a scientist, because they were all well educated.

The Society had its home in Gresham College for half a century, apart from temporary disturbances, minor disturbances like the Plague and the Great Fire; but in 1710 the Trustees and the Mercers' Company became very anxious about the dilapidated state of the buildings, the cost of repair, and had to tell the Royal Society that they could no longer have any room at the College. The President at the time was Issac Newton (he was president for 24 years), and he guided the Society in the purchase of its own house, Crane Court. This was very difficult for him, because the Fellows had become very attached to Gresham College and most of them did not want to leave it. That ended for two and a half centuries the close connection between the College and The Royal Society.

I am happy to say that we are holding discussions at the present time on how the Society and the newly-established Gresham College, in the Barbican at the present time, can work together again, particularly in forming links between the world of science and the City of London; most important at the present time; it has never been more important than it is today.

Science provides the power and the inspiration for manufacturing industry. The City provides the financial expertise and backing. They must work together. That is the theory, but it does not seem to be working out very well in this country, not as well as it is with some of our competitors. One asks why it is that although Britain has an unsurpassed record of Scientific discovery and invention over most of the last three centuries, and is still second only to the United States, we are among the developed Nations, near the bottom of the manufacturing league.

I believe that one of the principal causes of this, is that we are in some ways the worst educated country in the developed world, so highly specialised that the majority of our children leave school knowing almost nothing of mathematics, physics, chemistry, biology, medicine and engineering. They know so little when they leave that can never catch up. They have not got over the self perpetuating barrier, after which it is almost down hill to continues ones education. They will remain for ever ignorant of the modern world.

Well, some may say, why does this matter? It matters because many of them, highly intelligent, if narrowly educated, become leaders and opinion formers, in parliament, in the media, in the Church, in industry and in the City. Over the last 200 years pure and applied science have transformed the way in which we live. That is the good news, and it is so obvious that I need to say no more about it. The bad news is that the nature of this transformation and the role of science and technology in the modern world are very poorly understood by the majority of people. This is now so serious that it is threatening the advance, not only of science, but of civilisation and our success as an advanced nation, depending as we do on high technology.

The Popularisation of Science is not very popular, especially among scientists. Many scientists associate it with a lowering of standards. In French the word for popularisation is vulgarisation and that just about sums it up to some scientists. This attitude is not only quite mistaken in the world today, it is positively dangerous. Quite recently there has been a change of attitude among scientists, who are coming to realise that the public's view of science and of scientists is no longer a matter which they can ignore. The views of scientists alone are no longer sufficient to determine whether, for example, energy is delivered from nuclear power stations, or research involving animal experiments is permissible. Furthermore, scientific research is increasingly expensive, and most of it is financed by the taxpayer, who has a right to know how his investment is getting along. In a country

where the general scientific awareness and understanding are at such a low level, it is also likely to have a low level of industrial innovation and prosperity.

The popular presentation of science is no new thing. It has quite a long history, and it was in great demand by the end of the 18th century, when most gentlemen of leisure were as interested in science as they were in literature and the arts. In 1795 in her Letters for Literary Ladies, Maria Edgeworth wrote:

> "Our books of science were full of unintelligible jargon. Mystery veiled pompous ignorance from public contempt. But now writers must offer their discoveries to the public in distinct terms which everybody may understand. Technical language will no longer supply the place of knowledge."

It is interesting that as in the writing of novels, the ladies were rather active in this. Mrs Marcet wrote some excellent little books, Conversations in Chemistry, Conversations in Physiology and so forth. Mary Somerville was very active in writing on mathematics and, so forth. But although there was and still is today a popular interest in science, there is very little popular understanding. Scientists still seem very remote to most people.

Sir John Hill, a past Chairman of the United Kingdom Atomic Energy Authority, tells a story of how he was once travelling on a crowded train and he found himself in a carriage with a party from the local mental hospital. The nurse was checking her party, counting them. She counted them, one, two, three, and then she came to Sir John, and she said "who are you?" Sir John drew himself up and said "I am Chairman of the United Kingdom Atomic Energy Authority." She looked at him very sympathetically and went on counting, "four, five, six, ... "

Most of the population are ignorant of science. Many of them have that extreme form of ignorance, called fear. It is as well that scientists should recognise this. Science and technology are unpopular almost to the point of hatred in some sections of the community. I called this lecture "Popular and unpopular Science" and painful as it may be, I must dwell for a moment on the unpopular side, because we must face up to it. One need not even go further back than Dr Johnson who said:

> "The truth is, that the knowledge of external nature and of the sciences which that knowledge requires or includes, is not the great or frequent business of the mind."

The romantic poets had mixed opinions of science as well. Samuel Taylor Coleridge, a friend of his fellow poet and chemist, Humphrey Davy; who relished a whiff of laughing gas from time to time, and lectured badly at the Royal Institution; also had unfulfilled ambitions to own his own chemistry laboratory. However in his lecture notes of 1818 he wrote:

> " Poetry is not the proper antithesis to prose, but to science. Poetry is opposed to science, and prose to meter."

Their friend Wordsworth, who was indebted to Davy for corecting, puncuating and editing his Lyrical Ballads, because, as he said: "I

am ashamed to say, I am no adept at this" , could also write:

> " Science appears as what in truth she is. Not as our glory and our absolute boast, but as a subsidamian and a prop to our infirmity"

The family view of the Coleridges deterioated with time. The Honourable Stephen Coleridge, a great nephew of the poet writing about 1920, wrote:

> " The elevation of science to the supreme place in human affairs and the claims made for it to a dominant position in the education of the young, constitute a usurpation that threatens to become intolerable. Science drives full tilt towards the destruction of personal responsibility. It relegates every act of man to the inevitable results of fore-ordained courses. This is the world into which science seeks to force us, and a dreary world it is. In an evil hour, James Watt and George Stephenson between them, gave railways and factories to mankind, and the horrible results are seen in the ever-increasing vast agglomerations of miserable men and women in mean streets in the squalid centres of industry. In the murky canopy above them, there is never to be seen the blue sky."
>
> [all the scientists' fault. Of them he has this to say:]
>
> The solemnty with which they regard themselves, the exaulted titles of laudation they employ when speaking of each other, fill the foolish with amazement and admiration, and the judicious with mirth. They are illustrious and world famous. They pelt each other with degrees and diplomas, the whole country rings with their mutual hosannas, and the fountains of honour play upon them like a fire engine on a conflagration."

Henry Rycroft, writing in 1903 and published posthumously, said:

> "I hate and fear science, because of my conviction that for a long time to come, if not for ever, it will be the remorseless enemy of mankind. I see it destroying all simpleness and gentleness of life, all the beauty of the world. I see it restoring barbarism under the mask of civilisation. I see it darkening men's minds and hardening their hearts. I see it bringing a time of vast conflicts, which will pale into insignificance the thousand years of old, and as likely as not will whelm the laboriousness advances of mankind in bloodstained chaos."

More recently, in 1963, Robert Hutchins, who was a very well known President and Chancellor of the University of Chicago, wrote:

> "I do not know much about science, but I know a lot about scientists. I wish at the outset to repudiate C.P.Snow, who intimates in one of his books that scientists should be trusted with the world because they are a little better than other people. [C.P.Snow never said anything of the kind, but still, go on] My view, based on long and painful observation, is that professors are somewhat worse than other people, and that scientists are somewhat worse than other professors. C.P.Snow was right about the morality of the man of science within his

profession. There have been very few scientific frauds. This is because a man would be a fool to commit a scientific fraud, when he can commit frauds every day on his wife, his associates, the President of the university and the grocer. Scientists are worse than other professors, because they have special problems. One of these is that their productive lives often end at 35. A scientist has a limited education, he labours on the topic of his dissertation, wins the Nobel prize by the time that he is 35, and suddenly has nothing to do. He has no alternative but to spend the rest of his life making a nusiance of himself."

In case you think that all this is a thing of the past, let me quote from an article by Peter Simple, in the 'Way of the World' in the Daily Telegraph. He was commenting on the remarks made by the Bishop of Durham in his maiden speech to the House of Lords, in which the Bishop, rather surprisingly, chose as his subject the importance of training for the new technology, by a general insistence on literacy and numeracy.

> "It is clear", said the Bishop, "that to have the sort of collaboration that is required between the arts, social sciences, applied science and so on, they must be able to develop in the artist, a sense of what it is to be numerate".

Peter Simple's response to this was vitriolic. He harked back to the Levis and Snow contoversy and said that:

> "The Bishop might have questioned it, both in the name of his religion and of truly human life and civilisation. He might have asked his fellow Peers at least to pause for a moment in their worship of that received wisdom, and look about them at the world it has made for us, and the worse world it is making for our children."

So incomprehensible it may seem to those of us who love science, and see it as one of the few redeeming features in this rather unhappy world, for some people, science really is unpopular. I think this poor understanding and dislike which follows it, is the result of a culture gap.

"But what has science to do with culture?" ask those who know only one culture. They see little connection between the great thoughts of the philosophers and political historians, on which our future civil servants and politicians are reared, and the mundane matters of heat, light, electricity and stinks, which are to many quite a different matter, more associated with plumbing than the higher planes of intellectual social and artistic life.

Charles Snow has been much criticised for what seems to me to have been a statement of an obvious state of affairs. It is twenty years since his Reith Lectures, and it may be worth recalling what he said, because little has changed in that time.

Speaking of what he had called the 'Two Cultures' he said:

> "Constantly I have felt that I was moving among two groups, comparable in intelligence, identical in race, not grossly

different in social origins, earning about the same incomes, who almost ceased to communicate at all. Who in intellectual, moral, and psychological climate, had so little in common, that instead of going from Burlington House [which was where the Royal Society was ,in those days] or South Kensington, to Chelsea, one might have crossed an ocean. In fact one had travelled much farther than across an ocean, because after a few thousand Atlantic miles, one found Greenwich Village talking precisely the same language as Chelsea, and both having about as much communication with MIT as though the scientists spoke nothing but Tibetan. A good many times, I have been present at gatherings of people, who by the standards of a traditional culture, are thought highly educated, and who have with traditional gusto, been expressing their incredulity at the illiteracy of scientists. Once or twice, I have been provoked and have asked the company how many of them could describe the second law of thermodynamics. The response was cold. It was also negative. Yet I was asking something which is about the scientific equivalent of 'have you read a work of Shakespeare?' I now believe that if I had asked an even simple question such as 'what do you mean by mass, or acceleration?', (which is the scientific equivalent of saying "can you read?"), not more than one in ten of the highly educated would have felt that I was speaking the same language.

The most common ploy of the hard of understanding (scientifically speaking) is to begin by denying any knowledge whatever of scientific matters. There are then several alternative ploys which can be followed.
Firstly you can laugh it off, which is much the most effective way, if done well, by Bernard Levin, for example, when he says that a semi-conductor is a man who asks you to pass half way down the bus. Or one may boast about it as a normal,ignorant human being, or one may apologise about it. The latter course, may be disastrous, as is illustrated by President Richard Nixon when he was presenting the National Medal of Science in 1971. Referring to the citations acommpanying the medals, he said:

> "I have read them, and I want you to know that I do not understand them, but I want you to know to, that because I do not understand them, I realise how enormously important these contributions are to this nation."

That to me is the nature of science to the unsophisticated people. We have a long way to go.

There is another reaction to science which is a positive desire for the unknown. The mysticism, and all the mumbo-jumbo which separates primitive man from civilisation; Extra-sensory perception, Unidentified Flying Objects (which have to remain unidentified to qualify) and astrology, these are treated in depth and with apparent seriousness by many newspapers; as George Steiner has pointed out, there are more members of Astrological societies in the United States of America, than all the members of Societies of Physics, Chemistry and Astronomy put together.

During the last century, many of our best scientists became members of the Psychical Research Society, and encourasged the scientific study of such popular diversions as table turning, and spiritualism. (In those days, those who produced those wonders were called the media). The Society's investigations, assisted by such men as Michael Faraday, revealed nothing but fraud and deception. That is why there is very little investigation of these things today, - scientists are bored to tears with the whole thing and know that they are not going to get any very interesting results. If somebody presents them with a new phenomenon which they can reproduce; that, of course this is the stuff of success, thesis, papers and honours, but they would have to prove it first.

I spent the last twenty years as Director of the Royal Institution, where Michael Faraday, and his mentor Humphrey Davy, were two of the first to popularise science, especially for children. They were real pop-stars. Humphrey Davy was one of the most popular attractions in London at that time. When he was ill, bulletins had to be posted on the door to say how he was getting along. It is said that Albermarle Street, in London, became the first one-way street, because of the crowds who came to the lectures, and the horses had to set their heads facing Grafton Street.

Many of Faraday's remarks remind us how little has changed in the relations between science and government. You probably know the well-known answer he gave to Robert Peel, the Prime Minister, when the Prime Minister asked him that tiresome question which is still asked ad nausiam today, 'what is the use of your work?', and Faraday replied, 'I know not sir, but one day I warrant you will tax it'. He was absolutely right, and of course they do.

Faraday, for the poor public understanding of science, blamed the educational system. Giving evidence to the Public Schools Commission in 1862, he said:

> "The sciences make up life. The highly educated man fails to understand the simplest things of science, and has no particular aptitude for grasping them. I find the grown-up mind coming back to me with the same questions over and over again. Everything in these things must depend on the spirit and manner in which the instruction itself is conveyed and honoured. If you teach scientific knowledge without honouring scientific knowledge, as it is applied, you do more harm than good. Persons who have had the discipline of classical instruction, persons who have been educated by the present system, are ignorant of their ignorance at the end of all that education. That happens with men who are excellent mathematicians, until they know what are the laws of nature, and until they are taught by education what are the natural facts, they cannot clear their minds of absurd inconsistencies.
>
> I have had occasion to go over to France with a board, to look at their lighthouses, and we find intelligent men there, whom we cannot get here. In regard to the electric light, which you may have heard of, I have had to displace Keeper after Keeper for the purpose of getting those who could attend to it

intelligently. I trace everything to the ignorance of the learned in literature, as well as to the unlearned, and their want of judgement in natural things, where often there is a fine intellect in other things. Who are the men whose powers are really developed? Who are they who made the electric telegraph, the steam engine and the railroad? Are they the men who have been taught only latin and greek?"

The last great Director of the Royal Institution, was my immediate predecessor, Sir Lawrence Bragg. He was one of the first to put the blame for all this on the scientists themselves. He said:

"The importance of Science in everyday life is often stressed. The influence of advances in scientific knowledge on the achievements of engineering and technology has altered the way in which we live, and continues to do so with bewildering rapidity. At the same time it is also stressed that the man in the street has little conception of what science is and how it advances. Scientists are often the loudest in proclaiming this popular ignorance, especially when they want to get money to support their schemes. Yet scientists themselves are largely to blame for this state of affairs. They are often singularly inept at explaining to non-scientists what they are doing. Further, they are apt to regard colleagues who give popular talks, as actors aiming at popular applause, who cheapen science by over-simplification and spoil the dignity of its aloofness. I am quite out of sympathy with my fellow scientists when they adopt this attitude. I believe that it is our duty in return for the support that we are given to render an account of our stewardship, which is readily understandable by our fellow men who are intelligent and shrewd although they may not be familiar with all our technical terms.'

On Science and Industry, Bragg had this to say:

"Industrialists often say that fundamental research is attracting too many of the best men, stressing quite rightly that the life of the country depends on that high technical level of our industries. As I have heard it put, the worst brain drain in this country is to the Universities. I think the answer, however, is not to blame the Universities for making pure science too attractive, it is to increase the attractiveness of a scientific career in industry. Is there not still too great a gap between management on the one hand and research and development on the other. A Director must know enough about science to know what kind of questions a scientist can answer. If this is not so, the scientist cannot be inspired to give his best."

Sir Lawrence, of course, received countless honours, and one of the most unusual ones towards the end of his life, was to have a crater on the moon named after him. Lady Bragg, hearing about this, talking to me said "I think that is very nice for Willie, as long as he does not have to go and open it!"

When Sir Joseph Banks, who was the longest serving President of the Royal Society (for 42 years), learned of the popularisation of

science by Davy, that I referred to , he wrote to Rumford:

"The Royal Institutuion is now in the hands of the profane."

The Royal Society of London has not, in the past been noted for its pop image. But recently it decided that matters were serious,and as the leading scientific body of the country it should look into the problem. It formed a study group under the chairmanship of Sir Walter Bodmer, to review the public understanding of science in the United Kingdom. In its recommendations, the report of that committee - the Bodmer Report - mentioned a number of contributing proolems. Changes in our formal education system were desperately needed, to teach a broad course of science technology and the arts and humanities to all children, right up to the end of school. This, I am glad to say, the government are agreeing with and are beginning to implement.
Secondly the report stressed the importance of the mass media.
Thirdly, the point that Bragg was making, that it is up to scientists themselves to come out and play a greater part in the public understanding of science. In France, where most scientists are civil servants, this duty is now written into their contracts of employment. They have a duty to pronounce and explain to the public what they are doing.

This report is important, and one of the recommendations and consequences of the Bodmer report, was that a Committee should be set up to study these problems, and it has been set up. It is a joint committee on the Public Understanding of Science - called COPUS - a joint committee of the Royal Society, the Royal Institution and the British Association for the Advancement of Science. The committee has representitives of science, industry, government, media. Already it has taken quite a number of initiatives. It has instituted a Faraday award for the practising scientist who has done most to promote public understanding. We have a media fellowship scheme, for seconding scientists for short periods to work in the offices of the press and television. We have just instituted a science book prize, two prizes, one for children and one for adults. A competition for the best scientific and technological TV programmes, a big sort of OSCAR presentation which will be televised in the autumn, called SCITECH - televised in Bristol, and we have working parties looking into Science Musems, Exploratories and a number of other schemes of this kind.

I must mention one area of misunderstanding which is particularly relevant to the City. We are constantly told that we are good at science in this country, but bad at exploitation. Scientists are continually harangued by government and industry and told that they are doing the wrong research. It is becoming increasingly difficult to get adequate funding for good basic research, unless you can prove that there is an economic pay-off within about 18 months. Committees are being set up to decide for scientists what science is about, and what these scientists should be doing, the so-called ' exploring the exploitable areas' of science. But our failure can hardly be attributed to too much science, or that our science is too good. It is my belief that innovation in science can only occur from

the bottom up; not from Committees. The practising scientist knows best what is timely and promising in basic research. It is also my belief that the scientist is usually totally ignorant of market forces and needs, and that industry, and the City knows best what is worth exploiting at any given time. Of course there must be the closest co-operation between science and industry, but it is a mistake to thing that scientists in their ivory towers have no interest in the exploitation of their results. There is nothing that gives them greater pleasure than to find that their work is being exploited, and is useful, especially if they are paid a modest consultancy fee. They are absolutley delighted.

It has been said that there are really only two kinds of research; applied research and research which is not yet applied. But necessary as it is to their long term prosperity, individual industries, in hot competition with each other, cannot be expected to fund basic research which may have no payoff within the lifetime of the present board of directors. (Just as cabinet ministers and politicians do not have very much interest in Bills which are not going to show some popular appeal before the next election.) Therefore basic reseach must be done in the universities and research institutes, and it must be funded mainly by the taxpayer. On the other hand short-term research and development is best carried out by industry, and must be funded by them, and they know best what is exploitable. This is where our country fails, compared with Japan and our other strongest industrial competitors. The Japanese government spends far less on fundamental research than we do, but Japanese industry spends far, far more. Means must be found to encourage more of it. The City could help here, not only by providing finance, but by encouraging companies to declare in their annual reports their spending on Research and Development, and giving them some credit for doing so.

There are limits, of course, returning to the duties of the scientist, to what can be expected from anyone. It is not necessarily nor desirable for all scientists to take part in the task of the popularisation of science. Some are not good at it, and others are too busy with their own scientific work. Discovery and originality in science demand complete dedication ,at least during the critical period of time when the mind is engaged on the problem, and the advancement of knowledge is at least as important as imparting that knowledge to others. But they must be sympathetic with those scientists and the people in the media who do try to explain, even their own work; and they must encourage the professional communicators to do so without embellishment or exaggeration. The communicator must be fair by presenting the good news as well as the bad.

Let me take an example from my own subject, Chemistry. When did you last hear any good news about chemistry from the media? Naturally, and quite rightly we heard about the dreadful disaster in Bophal which killed 2500 people; probably the worst man-made disaster that has ever occurred in peace time. Worse still, the plant in Bophal was making chemical intermediates for insecticides, which are notorious polluters and destroyers of life. So all the news about

chemistry was bad. But look a little deeper into the purpose of Bophal.

Perhaps the most successful of man's achievements over the last two or three decades, in any field, has been the increased availability of food. Starvation is no longer necessary. The Green Revolution did exactly what the King of Brobdignad of Gulliver's Travels, had asked for, and made two ears of corn or two blades of grass grow where only one grew before. Those who brought it about, according to the King, would deserve better of mankind and do a more essential service to the country than a whole race of politicians put together. This was a proud achievement in chemistry, depending heavily on fertilisers and new insecticides, plant-growth substances and the like. Since the War, the improvement of food productivity has been dramatic. Since 1964, worldwide production of wheat and food grains has doubled and kept ahead of population growth. In the EEC, wheat production has doubled in seven years. In Britain, the same area of land yields twice as much wheat or potatoes, the cow gives twice as much milk on less land. It is the same story round the world in those countries which used to be held up as unable to feed themselves. China is now expected to produce the largest wheat crop in the world, and is in the export food business. India is effectively self sufficient. Pakistan, Brazil, Argentina are already exporting food, or will shortly be doing so. The world is awash with surplus food. Of course there are distribution difficulties, but we produce more than we can eat if properly shared.

How did mankind welcome these achievements? Did everyone thank the chemist and congratulate him on what had been done for the benefit of mankind? Well not really; a decade or two ago a period of depression began about science and technology as a whole; the post-industrial revolution was discovered. People like Rachel Carson and Alvin Tophler, Theodore Rosak and the Club of Rome, and many others, questioned not only some genuinely worrying aspects of chemical polution, but often the whole ethic of modern technology. Quite quickly, the idea of better living through chemistry promoted by the DuPont Company and generally accepted, was transformed into an association of chemistry in the public mind with pollution and the iniquities of multi-national corporations. Many of the essentials to the Green Revolution, such as insecticides, became in the laymans mind, destroyers of life.

But high crop yields depend on those pesticides, as much as on fertilisers, because food plants have to compete with weeds and pests and viruses. Without them, as Max Perutz has pointed out, the production of grain would fall by nearly a half in three years. We would have a famine of catastrophic proportions, like the Irish Potato famine, which was also caused by a fungal infection.

The memory of how the people of the world suffered without science is soon lost, and the young people today never knew it. They see only the remaining problems and human errors, some of which we can

solve and prevent, but some of which we shall always have to live with. It is ethically no more justified to take life by intentionally doing nothing, than by some positive action which intentionally causes death.

On the economic front, too, it needs to be more generally known that the chemical industry of this country contributes more to the balance of payments than the whole of the rest of manufacturing industry put together. But a public which has become accustomed to scientific answers in black and white, is not prepared to discuss technological risks in various shades of grey. Somehow the message has got to be got over, because in a democracy the people decide. An uninformed decision may sentence millions to starvation. The scientist and the media must understand that their purpose and their professions are very different. But they must try to work better together inspite of this to inform the public. Einstein once said: "Everything should be made as simple as possible, but not simpler". The media must not mistake superficiality for popularisation.

Just having more science is not enough. I have seen lectures which have probably put the audience off science. Enrico Fermi once stood up after a lecture and pronounced: "Before I came here I was confused about this subject. I am still confused, but on a higher level." The real permanent solution must lie with the educators in our schools. Children are born scientists. They have to be if they are to grow up and become independent. They have to learn, partly from their parents, but mainly by experiment about the natural world about them. If they do not learn about the laws of gravity, they will not learn how to stand up; and the laws of motion, they will not learn how to walk. If they do not learn about the viscosity of liquids, they will not be able to feed themselves, they will slobber. A small baby, given a woolly toy will investigate it with the limited techniques at his disposal, he will probably chew it and smell it and squash it, and so begin his learning of chemistry and the laws of motion and the properties of materials. Before long the young child will be doing experiments not for reward, not even to gain a practical objective, but out of natural inquisitiveness. Young people continue their interest in science for several years, frequently asking philosophical questions, which have no immediate application and which their parents cannot answer. "Don't ask such silly questions", and so comes the great divide. A small proportion do continue to ask these questions all their lives, whilst a much larger number give up all interest, or is it hope, in further understanding of the natural world and themselves. These are not necessarily less intelligent, many will be succesful in other ways; many will leads us as politicians, opinion makers in the media, and teachers. There are talented and educated teachers. They are of an enormous importance and there are far too few of them.

I remember my first teachers at the age of ten or eleven, by name. I remember almost everything they said in the first lessons. Perhaps the greatest genius of all was my mathematics teacher a Mr Tomkiss.

I remember how he taught algebra, I remember how he taught geometry. One particular point that he made about algebra, was that if you multiply one side of an equation by two, you must multiply the other side of the equation by two, and if some miserable boy did not do that, he would say: "Come out. Ttake out your slipper, bend over. What you do to one side, you always do to the other!" The point still clings to me.

Science is growing rapidly. We must all grow up with it. Above all we must help people to understand, not so much the facts of science, but what it is about. Science can and does make our lives more comfortable by removing causes of unhappiness, like hunger and disease. It cannot guarantee to make us happy, but it can certainly relieve much unhappiness. But removing hunger or disease is not its only or its main purpose. We need to tell of science as a great Oddyssy, a search for truth and understanding of ourselves and of our universe.

Those wonderful words of Wenevar Bush:

> "Science is a simple faith which transcends utility. Nearly all men of science have it. All men of learning for that matter, and men of simple ways too. It is the faith that it is the privilege of man to understand and that this is his mission. Why does the shepherd at night ponder the stars? Not so that he can better tend his sheep. Knowledge for the sake of understanding, not merely to prevail, that is the essence of our being. None can define its limits or set its ultimate boundaries".

In the words of Tolstoy:

> " The world has but one science, the science of the whole, the science explaining the creation and man's place in it".

----ooo00ooo----

GRESHAM COLLEGE

Policy & Objectives

An independently funded educational institution, Gresham College exists

- to continue the free public lectures which have been given for 400 years, and to reinterpret the 'new learning' of Sir Thomas Gresham's day in contemporary terms;

- to engage in study, teaching and research, particularly in those disciplines represented by the Gresham Professors;

- to foster academic consideration of contemporary problems;

- to challenge those who live or work in the City of London to engage in intellectual debate on those subjects in which the City has a proper concern; and to provide a window on the City for learned societies, both national and international.

Founded 1597

Gresham College, Barnard's Inn Hall, Holborn, London EC1N 2HH
Tel: 020 7831 0575 Fax: 020 7831 5208
e-mail: enquiries@gresham.ac.uk
Web site : www.gresham.ac.uk