

## “Creativity in Education, the Key to an Enlightened Global Community”

### Introduction

It is a pleasure to be here and give this presentation. This is a rather serious lecture, and when I do introduce serious lectures I often start with my favorite quotation:

*If you make people think they're thinking  
- they love you.  
But if you really make them think  
- they hate you!*

(Don Marquis)

I think many of you may have experienced this situation in heated discussions and I should also say that I am not here to make you feel comfortable, I am here to make you think. I want you to think about a lot of important issues, in particular the subject of this lecture:

### “Creativity in Education, the Key to an Enlightened Global Community”

We shall discuss the issue of Peace also. The main task of a teacher, I think, is to unlock the creative potential of each and every young person. It's not the only one, but it is one of the most important ones, if not the most important one. I love this set of photographs which my wife Margaret took of a little girl in Delft the town in which Vermeer lived. This three year old was totally engrossed in a creative hands-on model-building exercise



Photographer: Margaret Kroto

Take a close look at this wonderful final image as it has captured a vital moment when this youngster expressed pure joy when she finally saw the exquisitely beautiful object that she had herself created. This image epitomizes what education is all about.

An associated issue I wish to address, and one which Americans are very keen on, is “leadership”. Unfortunately there are not many people who really understand what leadership is or should be in an “Enlightened” world. I see the role of “a leader” as that of a teacher, whose main aim must be to nurture the ability of students to think for themselves so the student

can decide on issues for themselves and have no need to be led. After all, what merit is there in leading a flock of sheep? Students must not be treated like sheep and they must be taught not to be sheep. Advances in society – technical, societal or humanitarian are not achieved by sheep as sheep are easily led astray.

Now, let's talk about "Enlightenment". The philosopher Immanuel Kant wrote an important essay about "the Enlightenment" and what it is. He wrote (in German): "Aufklärung ist der Ausgang des Menschen aus seiner selbst verschuldeten Unmündigkeit". "Unmündigkeit" is not so easy to translate into English, indeed often some words are not perfectly translatable. The best I can do (paraphrased in the English idiom) is: "One is enlightened when one emerges from one's self-imposed mental immaturity. This immaturity is the inability to use one's own understanding without another's guidance." What is involved in education is to teach students how to become responsible citizens; citizens who can make wise decisions without being told by others what they should think and do. This is very important. Kant goes on to say "This immaturity is self-imposed if its cause lies not in lack of understanding in decision-making but in a lack of courage to use one's own judgement without another's guidance".

"Do we live in an Enlightened age or in an age of Enlightenment?" Kant argues that in 1784 in Prussia people lived in an Age of Enlightenment, meaning they were in the process of becoming enlightened, but had not yet achieved this state. I believe that we still have a problem. I think we might even be going backwards and I think young people today need to be encouraged to think for themselves. Indeed I think this may be the major issue for society today.

### **Creativity and Synthesis**

Let us discuss creativity. Creativity involves synthesis and education does too. When you think about being creative and how we should teach, I think we should try to make sure that young people are interested in as many areas as possible: Science, art, film, music, humour, writing, sport graphics and books etc. People should be as multidimensional as possible in their interests and activities and they must explore as many creative avenues as possible.

Synthesis is the key to creativity and a favourite examples of synthesis is a chemical one: In a vine, carbon dioxide and water react together, the energy needed provided by photons (from sunlight), to produce a carbohydrate in the grapes. In the second step the carbohydrate, in the presence of an enzyme, is transformed into alcohol, and the result is that one can enjoy a glass of wine.



In synthesis two or more things, in this case carbon dioxide and water but they could also be anything such as ideas, are combined to create something with new properties above and beyond those of the starting materials. This is the basis of the creative processes in all areas from the Arts to the Sciences.

### **Education - Creating the Prepared Mind**

Pasteur said: "In the field of observation chance favors only the prepared mind". Preparing the mind is what education is all about. How do we, as teachers, how do you as students, prepare our/your mind? Well, I am going to tell you something about me. Yes, I used to be as young as some of you young people in the audience, I was once even younger, though that may seem hard to believe! My head teacher at that time wrote to my mother (I was called Krotoschiner then):

Wolffenden St. School  
Bolton  
2. 6. 47.

Dear Mrs. Krotoschiner, Miss Bowker  
thinks I had better write and tell  
you that we are not at all  
pleased with the way Harold has  
been working during the last few  
weeks. He is very fond of play.

In fact, however I think basically that's what we have to do in life to be creative. We have to make sure that our lessons are about play. At the time I was the only person with a funny name in my class. All the others had typical English names, like Thomason, Chadderton, Entwistle, Thistlethwaite, Smith etc and then came Krotoschiner. Who's that? What is he doing here? Believe it or not, I didn't always want to be a scientist. What I really wanted to be when I was small was Superman. I am a scientist now, therefore I need to show you evidence for everything I claim and so I thought I show this photograph of me trying to be Superman!



I couldn't fly so I had to do something else. I played tennis, and I did gymnastics

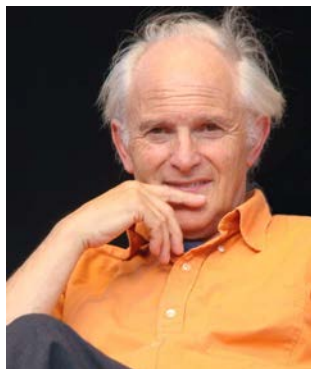


and I also acted in a play Henry the Vth, the famous play by Shakespeare, and I thought I would blow this picture up...



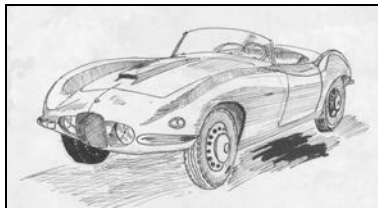
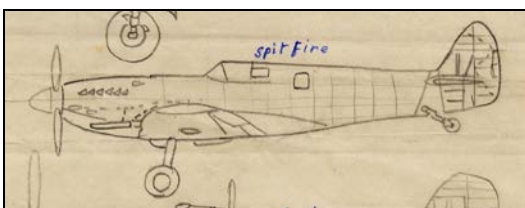


I am the handsome guy just behind Henry by the way in case you didn't recognize me and I always tell young people that if they want to be an actor they should think twice as the guy in front of me in this picture did become a professional actor and he is now about 5000 years old



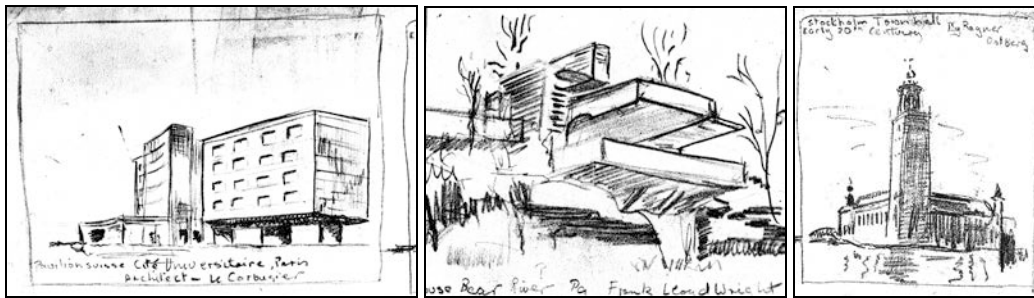
and I am not quite so old. In fact Ian McKellen and I were in the same year in school. He is arguably the greatest British actor of my generation and he came out to Tallahassee and did a wonderful one-man show for the students at Florida State a couple of years back.

I did many things at school but in particular my main interest was drawing. As many small boys do I drew cars and planes and as I grew older girls (!) but when I only got a "Good" from the teacher for my frog



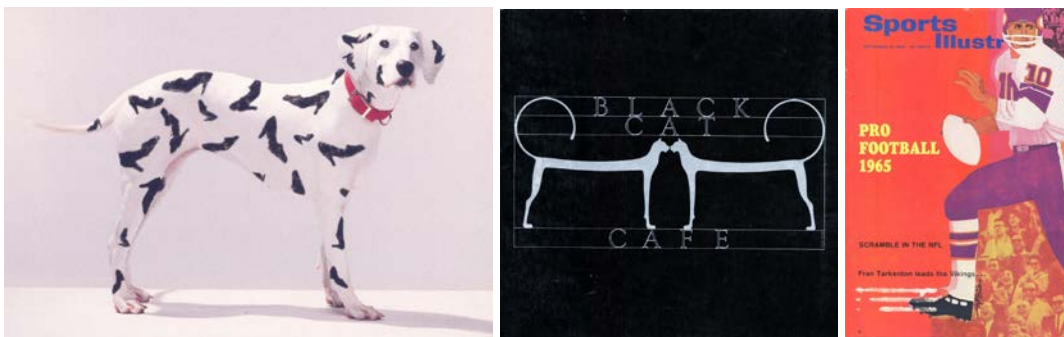


I was a bit irritated as I thought it should have got "very good". I also drew buildings as I was interested in architecture, and here is a building designed by Le Corbusier as well as Frank Lloyd Wright's famous house Falling Water. Curiously and perhaps also prophetically I also drew Stockholm Town Hall, where each year the Nobel Prize is awarded, when I was about 13 years old and long before I knew anything about the prize.

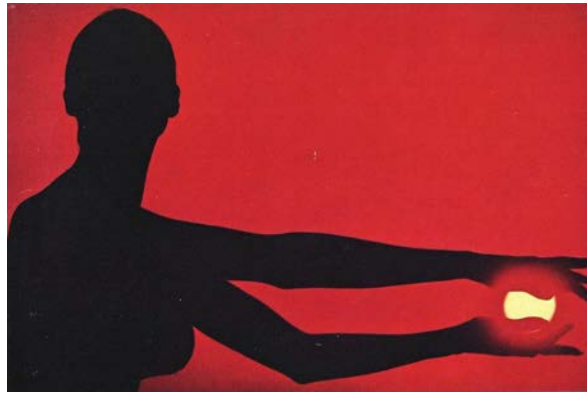


**Collecting Printed Ephemera – an Education in Graphic Design**

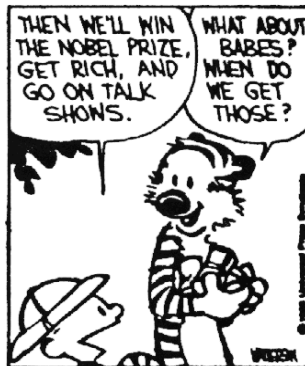
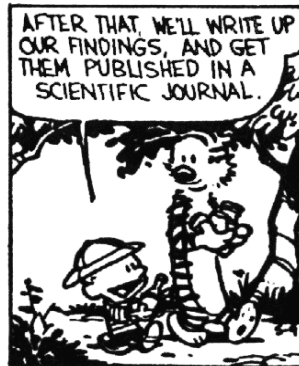
I also loved to collect all sorts of illustrations and examples of graphics, anything and everything which I thought was creative, particularly when it was free. It is wonderful, there are works of art right under your nose, and often you do not have to buy them. You don't have to go to big galleries, small ones often have free cards and brochures about the exhibition on at the time. Cafes often are happy to let you have their menus.



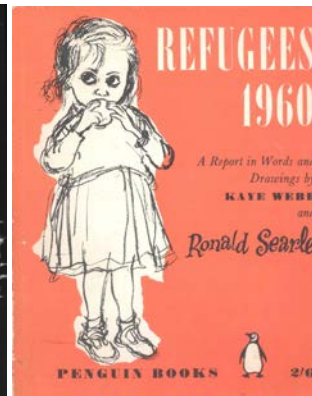
Look in magazines, look in books! You can go into art galleries, and you get many beautiful works of art free! Here above are a free postcard, a free menu and the cover of a magazine drawn by a favourite artist of mine Bob Peak (mind you I did have to buy this one). I have been collecting printed ephemera ever since I was 10 years old and younger, and I treasure much of the free materials just as much as some of the things that I paid for. Below is famous magazine cover about "Swinging" London in the 60's - a reason for our return to the UK from the USA when I was a postdoctoral fellow in 1967. When we got back we discovered it wasn't swinging as much as the hype at the time made out. Next to this cover is my favorite image of the Sun (from Queen Magazine), the most imaginative and beautiful image I have ever seen of our Sun. The act of seeing and appreciating these images was not just about collecting it was much more to do with the primary process which developed my feeling for graphic art and design instincts.



I also collect cartoons and comic strips such as this great one of Calvin and Hobbes



Clearly Hobbs has the right priorities! I collected all sorts of photographic images such as this powerful scene from the Stanley Kubrick film "Dr. Strangelove". As a fisticuffs break out among the participants in the meeting a voice shouts out: "Gentlemen, you can't fight here! It's the War Room!" One of the most powerfully ironic moments in a fantastic movie.



One of the very first books that I bought myself was "Refugees" illustrated by the fine artist Ronald Searle who actually survived as a prisoner on the Burma Railroad. It is one of my most treasured possessions and it was "only" 2/6 – two shillings and six pence or 1/8 of a pound at the time. It is treasured partly because it was one of the first books I ever bought for myself but also mainly because of the intrinsically humanitarian drawings of refugees; an issue which is unfortunately arguably even more of a problem today than it was when I bought the book some 60 or more years ago. Much of the stuff that I have collected is of the kind that others dump in the trashcan, so I call it "Trashcan Art". Don't throw it stuff you like away! Keep it and enjoy the pleasure of looking at it or reading it again from time-to-time and when you die, let someone else have to treasure after you.

### Technology, Today and Yesterday

One of the most important things I had was the camera and I want to tell you something about "real" photography. At the start of the set of images below is my first camera, a Voigtländer, given to me by my mother. In this set of 48 images one can follow the individual steps which were involved in creating a photograph when I was young, in the pre-digital age! You had to go through all these steps: Load the film into the camera in a dark room, focus the camera by estimating the settings for the exposure time, aperture and distance of the object; then actually take the picture at the end of the exercise



one had to take the film out of the camera in a dark room and insert it into a developing tank; then develop and fix it while in the tank; take the negative film out squeegee off the liquid and dry it; then print the positives in a printing frame (I did not have an enlarger when I was young) develop the image, fix it and dry it. (Note also that I had to determine the exposure time here too). Real chemistry was involved in all this and a lot of really fundamental science and technical understanding. "How many in the audience have done that? Hmmm everybody like me over the age of 325, I guess".



*The numerous steps that in the past one had to carry out to produce a photographic image*

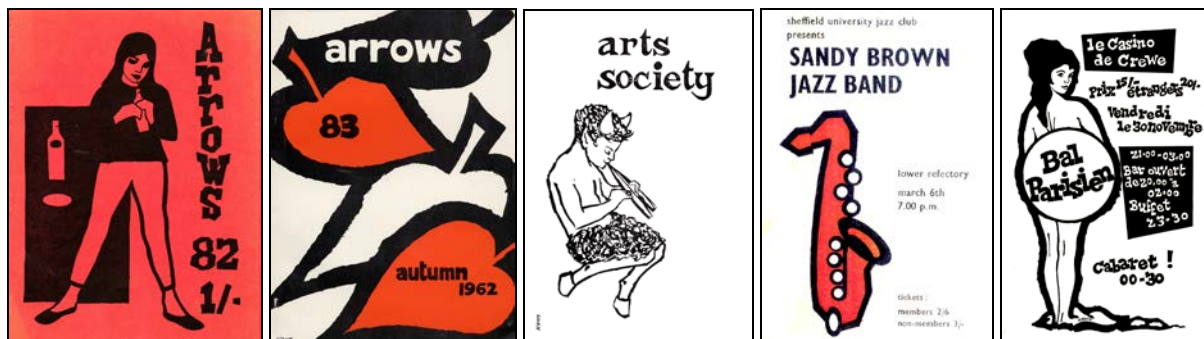
Well to go to all this effort one had to have a very good incentive and I did have a very pretty one and she is here in the audience, (points to Margaret Kroto):



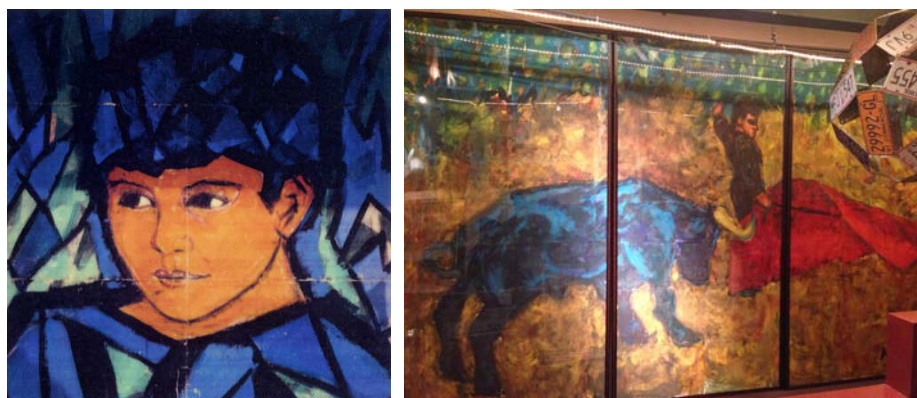
Today however all that one has to do is to do is press a key on a mobile phone. And so much has been lost. Many of you, in fact probably most of you, do not understand what is going on inside the phone. In fact I do not know much of what is going on inside a mobile phone. It is very complex electronics. However I knew essentially everything about the photographic process: The chemistry involved; the interaction of photons with silver bromide crystals; how to calculate the correct exposure time settings, focus the camera even more complex but important problems such as reciprocity failure and so on. I think that the change in photography from analogue to digital epitomises the major pros and major cons of life in our highly technologically dependent environment today: This is that the technology that we have around us and on which we now are almost totally dependent is essentially impossible to understand and when it malfunctions it is almost always impossible to repair. All that can be done when it malfunctions is to throw away and replace it with the up to date version. Furthermore all small children are curious but a small child has no chance of understanding how a mobile phone works by opening it up. So curiosity, that fundamental and essential catalyst of creativity, often withers away and many young people never develop an appreciation for the amazing genius involved in the creation of our advanced devices. They then just take these things for granted. We need to recognize that it is by repairing devices when they go wrong that we learn how they work and as our world is now full to the brim with unrepairable devices we are inevitably sliding into a state of complete ignorance of how our world actually works. I suspect this is very dangerous because we shall make major mistakes when it comes to solving major technical problems if we do not understand them well.

### **The Advantage of a University Education**

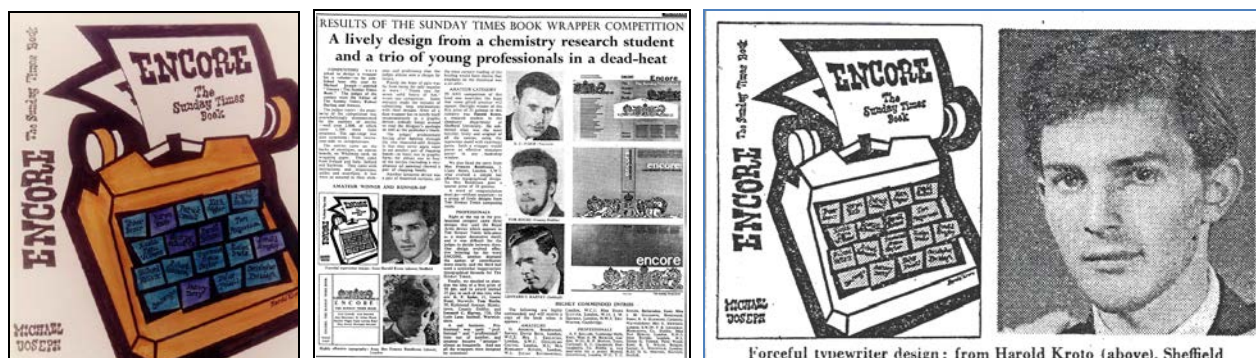
University is the best place to explore all avenues of your creative potential. When I was at Sheffield University I tried to do as much as I could. As well as my course work in Chemistry I was the art editor for the student magazine "Arrows". Here are some designs the covers of the magazine as well as some other printed items such as brochures, event tickets and posters.



I also painted very large murals for events such as student events such as dances. The two below are some eight feet high. The bullfight mural now hangs in the "Artisan Works" Galley in Rochester New York where this photograph was taken. Artisan Works is a truly amazing museum, the brainchild of Louis Perticone a man of incredible energy, imagination, personality and endearing charisma who has filled innumerable connected buildings with art and artefacts of all kinds and gives space for local artists to create.



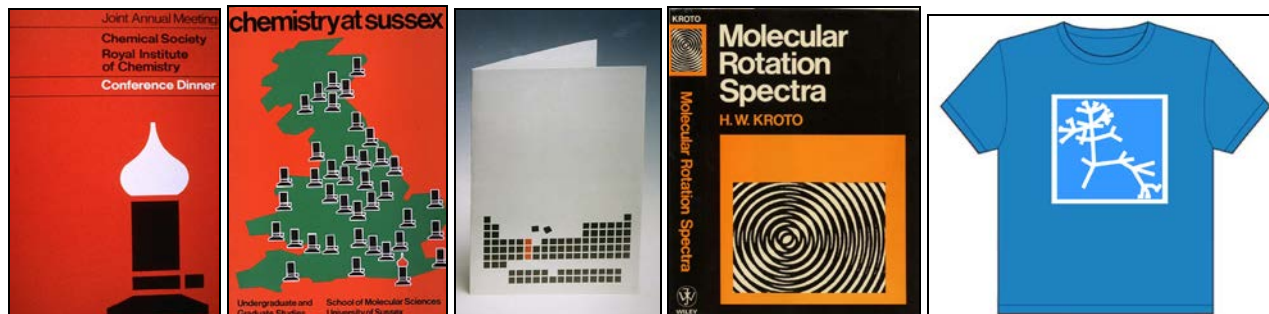
The first important award I received was not for science but it for the book jacket design (below) which was a compendium of articles reprinted from the (pre-Murdoch!) Sunday Times in which the authors' names were on the typewriter keys. Here is also the Newspaper cutting and yes I used to look like this. Yes, I did believe it or not; I know it's hard to believe. Many of you are young and beautiful now but you are going to look old and decrepit like me one day. Your youth and beauty will not last, so enjoy it whilst you can!



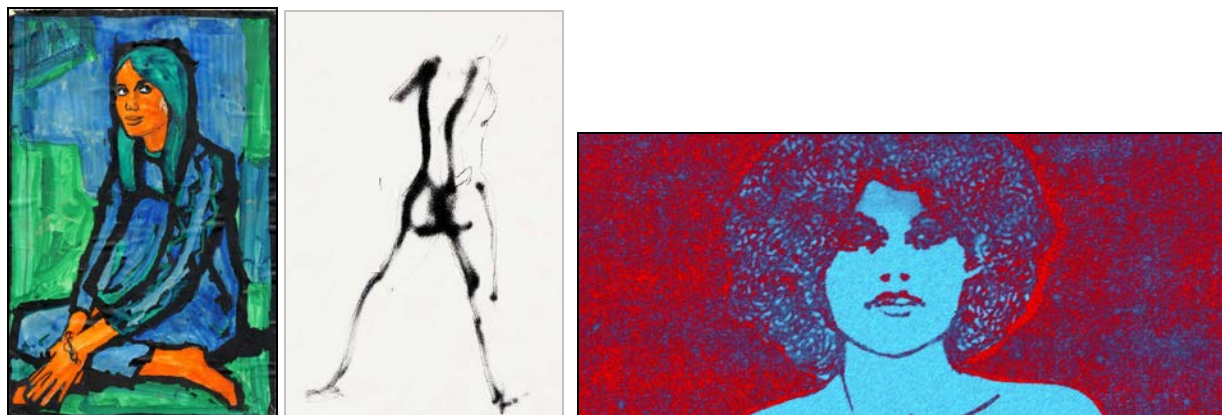
Forceful typewriter design: from Harold Kroto (above), Sheffield



I continue to design to this day such the set below: A logo and menu for a chemistry conference in Brighton UK where the shape of the Bunsen burner flame evoked the shape of the dome on the Pavilion which was designed in the form of Moghul Palaces and is the iconic trademark of Brighton, The cover for a "Chemistry at Sussex" brochure which was featured in an international annual of graphic design (the Bunsen burners indicated universities with chemistry departments and the only one lit was at Sussex in Brighton!); a menu for a chemistry conference on the elements Chromium, Molybdenum and Tungsten and the displaced elements from the Periodic Table form an anagram of the word MENU (Mn and Eu); the cover of my book and a T shirt with my stylised logo of Darwin's phylogenetic tree drawing on it.



I particularly like drawing faces and here are a few below; the first of this set of four is of my wife Margaret and the last of a colleague at Sussex. All these images were really experiments in graphic techniques



It is very easy at university to develop a range of avenues of interest and expertise but much more difficult when one leaves and gets a job with responsibility.

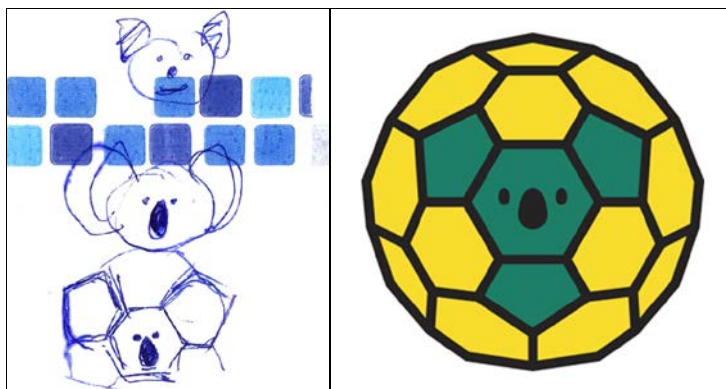
### Logos

I particularly like designing logos and the secret of a good logo is a subtle synthesis, often the conflation of an appropriate set of letters with an appropriate symbolic image. The relationship should be stretched just sufficiently to make the viewer think, but not so far that the relationship is impossible to work out. The viewer gets an intellectual charge by solving the analogy puzzle which is transferred positively to the organisation being represented. In the set below: a) In the case of the "Kroto Research Institute" (kri) at Sheffield University the letter "r" is dropping a "drop" into the test tube letter "i" so evoking chemistry, one of the main areas of research at the kri. b) This logo was for a conference on the population explosion was unfortunately not used; c) I designed this one for my wife who is on the board of Association Française Tallahassee. Here I have found a way of invoking the letter F together with the colours of the flag of France. Note that the letter F is not actually there. d) I have used a Buckyball (for which I and my colleagues were awarded the 1996 Nobel Prize in Chemistry) half-dome to represent the overarching range of areas researched at the campus at Sheffield University; e) This logo uses the

letters VEGA to form the main part of a star image. This was designed for my [www.vega.org.uk](http://www.vega.org.uk) website as when Vega was created originally is broadcasted science programmes on the BBC late at night and Vega is one of the brightest stars in the night sky; f) This is my reworking of Leonardo da Vinci's brilliant Vetruvian man. I have placed his image inside our buckyball for a poster for one of my own lectures; g) This logo was designed for the Florida Center for Research in Science, Technology, Engineering and Math(s). I have used arguably the first curve we learn about in mathematics and physics. This is the elegant quadratic curve ( $F(x) = kx^2$ ) which describes the energy of a simple harmonic oscillator (SHO), the basic motion of any vibrating body when displaced from equilibrium. These systems are governed by Hooke's Law. In fact the first test that Heisenberg carried out using his breakthrough derivation of Quantum Mechanics was the calculation of the eigenvalues (quantized energy levels) was of the SHO. h) My BREAKTHROUGH logo was designed for a fundamental science funding organization. If only the G could have been a C, it would have ended in OUCH! i) I also designed a UK stamp for the centenary of the Nobel Prize, and j) Oh yes I also re-designed the Japanese flag too!



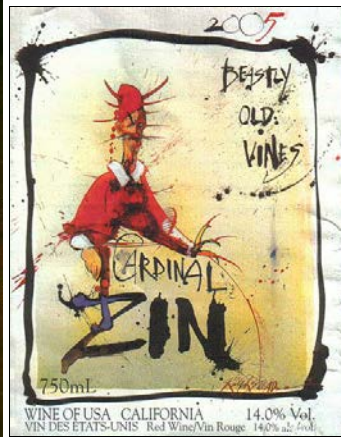
I thought I should show you how one of my all-time favourite logos was created. A few years ago I was asked to present a Science (Buckyball) Workshop for some 2000 young children in ca 30 schools across the whole of Australia via the Internet and thought it would be nice to design a logo for event. I was in a restaurant when I started the design by doodling on a napkin. It ended up as this synthesis of a koala bear on an a Buckyball in the Australian national colours. I am hoping to sell it to the Australian Football Team! These are the sort of things that I really enjoy doing and it is all about synthesis.



### Art and Artists

I want to talk more about art because you cannot be an "Enlightened" human being in this world without an appreciation of the visual arts and graphics as well as other things such as nature and the physical world. I want to show you some of my favorite paintings, what I call my "Top One" painting. One is of Pope Innocent X by Velázquez which is arguably the greatest portrait ever painted. Another favourite artist is Ralph Steadman who created a label for a wine bottle and see can see it is a pastiche of Velázquez's painting. Note the accentuated eyebrows and the hands. The artist notices features that many people miss. This wine label was banned in the State of Ohio! One might conjecture over the reason why!





Another of my favorite paintings is this one by Jack Vettriano and you might ask why I admire it? Well, let's study the hands of the man and what he is holding. He appears to have just finished painting his beloved veteran car and is standing back to admire what he has done. What we recognize is pride in what he has achieved. An evocation of pride without seeing the man's face! The pride is cleverly reflected from the back in the way the man is holding the cigarette and the angle of the paintbrush. It is probably the same emotion as the little girl in the first set of images in this article. Edward Hopper's "Nighthawks", is in my opinion "The" great American painting. What we see in this close-up segment is a rendering of loneliness. This is a brilliant depiction of what is unfortunately an all too common human condition. The last image in this set is my favorite English painting: "The Badminton Game" by David Inshaw. When I see this image it always reminds me of our home on the edge of the Downs in England on a beautiful Summer day. Of course England is not known for many sunny Summer days but they do actually occur occasionally and when they do it is something to savour. English weather I guess can be roughly characterised as: In any five years one Summer will be fantastic, and one pretty grotty and the remaining three somewhere in between".

The human dimension of art is vital and a truly great painting must possess a spiritual dimension. Not spiritual in the mystical or religious sense (as I am an atheist) but in one that reflects a deep perspective on the human condition or some evocation of human experience or perception of humanity and/or inhumanity. For me the greatest painting of the 20<sup>th</sup> century is "Guernica" by Pablo Picasso. In 1936 Guernica, the holy city of the Basque people, was bombed to the ground by the fascists.





This painting only arrived in Spain after the Franco died. A copy was on the second floor of the United Nations building in New York just outside the Security Council. It appears to be no longer there and one might ruminate over why this might be! This painting presents one of the most graphic and chilling evocations of the horrors of war. Look at it carefully; can there be any more powerful depiction of the grief of a mother whose child has just been killed than the image on the far left. Art can achieve things which a realistic photograph cannot. We see a dying soldier on the far right and a dead soldier on the ground. Horse screaming as a spear enters its body. I would argue that this painting is the greatest painting of the 20<sup>th</sup> century because it captures a spiritual aspect, portraying the age-old addiction of human beings to solving their issues by sending (in general) young people to kill each other war. It is for me THE icon of the 20<sup>th</sup> Century which saw two terrible World Wars with the needless loss of millions of young lives. As the son of parents who came to Britain as refugees from Germany in 1937 I see this painting as the most powerful statement of the senselessness of the deaths and murders of countless millions of human beings that have been the result of wars and intrinsic inhumanity through the ages.

One day our elder son Stephen recognized Ron Kitaj while we were in a coffee bar in LA some years ago and we all became good friends and in fact we recorded an interview with him describing the paintings in his collection in his LA Westwood home. This painting entitled "Marinka Smoking", is one of my favorites, indeed I consider this one of the most beautiful images of a woman's back ever painted, second only to Velasquez's "Venus".



Paul Wunderlich and Karin Szekessy also became good friends. Here I am working together with Paul on one of his prints and next to an airbrush painting which Paul created just for me as well as a self-portrait.



Karin is a famous photographer in her own right and Paul often uses Karin's images as a source of inspiration and this synergistic process has been documented in their book "Transformations" or in German "Korrespondenzen". The beautiful "lichtdruck" of Karin's on the left, a copy of which we have, was stimulus for my all-time favorite painting. This is the painting, which more than any other, I would wish to have on my wall and see every day! Let us look at it in detail. It is called "Streichholz" which is German word for matchstick. Look at the brilliant way that the iridescent colours of flame of the match form the iris of the woman's eye. The surreality of the burning matchstick hanging in the air and the wisps of smoke leading the eye from the cigarette across the body of the elegant woman towards her face is extraordinarily beautiful. These images lead back to David's famous painting of "Madam Recamier". So my favourite painting is a perfect example of the main thesis of this presentation that "Synthesis" lies at the heart of the creative process.



Here is a favorite poster which also hangs on our wall. It is by the artist Folon whom we once met and with whom we had dinner. There is a beautiful Folon Museum near Brussels which everyone should visit.



Folon created many sculptures also and here is one which captures beautifully the beautifully gentle and whimsically human and humorous art of Folon. Margaret took a favourite photograph of me from the back with one of Folon's sculptures. That is what art is all about.

Roger Dean who is famous for his brilliant graphics lives in our town, Lewes, in England, and here is one of his great record covers designs, "The flying elephants" for the group Osibisa. I also love this amazing depiction of a hybrid of a bird's skull and the SR71 Blackbird. It reminds me of the way in which pelicans swoop down and dive into the sea to catch fish as in this photograph taken by our elder son Stephen. If you have ever watched pelicans diving it is a truly amazing sight.



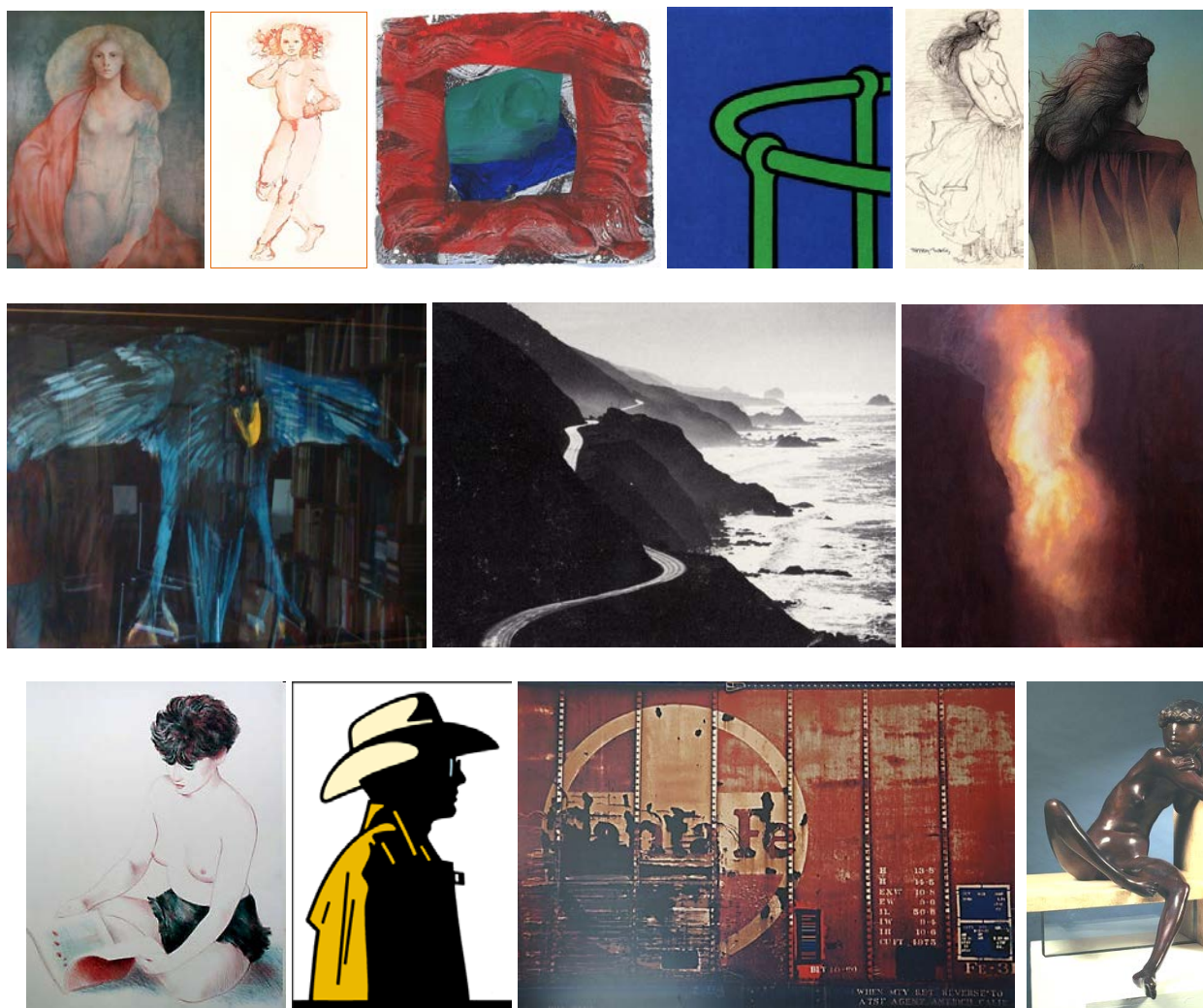
Photograph Stephen Kroto

The beauty of the SR71 Blackbird, the fastest aeroplane ever built which holds the record for round the world flight, reminds this overgrown techie schoolboy of the seductive nature of our weapons of war as expressed so ironically by Leonard Cohen, especially in the Jennifer Warnes rendering:

I'm guided by a signal in the heavens  
 I'm guided by this birthmark on my skin  
 I'm guided by the beauty of our weapons  
 First we take Manhattan, then we take Berlin



I cannot end this section without some of the other images which adorn our walls

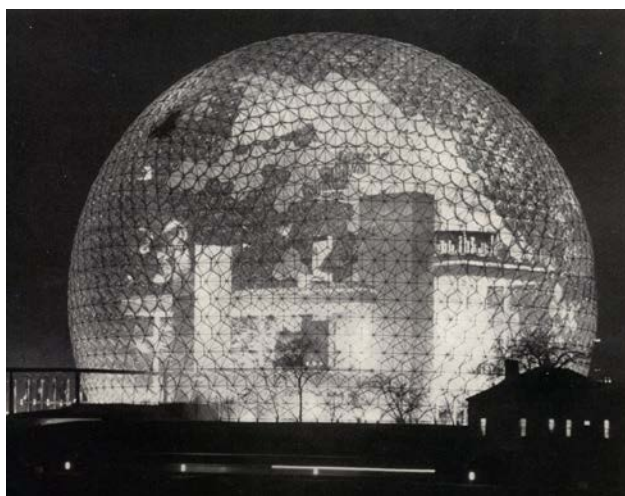
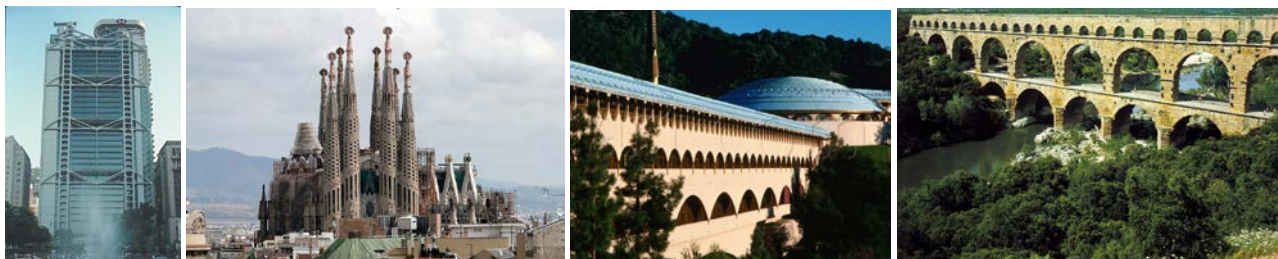


In order are two images by Leonor Fini (the second "Red Dancer"), an abstract by Howard Hodgkin, a print by Patrick Caulfield, a copy of a drawing by Jeffrey Jones, a print by Bruno Bruni, a water colour entitled "Rising Crow" by Leonard Baskin, probably the most famous photograph of Highway 1 (PCH) in California by Howard Gilpin, an oil painting "Dancer" by Patrick O'Donnell, a print "Girl Reading" by Adrian George; a screenprint by Michael Schwab; another screenprint "Santa Fe" by Andrew Holmes and finally a sculpture "Leaning Girl" by Ralph Brown.

### Architecture

Now I come to architecture, because that is another interest of mine and one which turned out to be very important in my scientific career. As indicated earlier, as a teenager sometimes drew buildings. Here are some favourite architectural masterpieces: The Hongkong-Shanghai Bank by Norman Foster, the Sagrada Familia by Gaudi, and perhaps my all-time favourite, the wonderful Marin County Civic Centre by Frank Lloyd Wright. This is a brilliant modern rendering of the elegant Roman aqueduct designs as the Civic Centre nestles in a complicated small valley a few miles north of the Golden Gate Bridge just off Highway 101. This building features in the oddly interesting science fiction movie "Gattaca". The final architectural image which is the key one in my personal academic journey is of Buckminster Fuller's geodesic dome at Expo 67 in Montreal which we visited and went inside. This building and this particular striking nighttime image which is featured in a special edition of the most important graphic art and design magazine "Graphis" was at least for me the most important clue to the structure of a molecule with 60 carbon atoms which we discovered in September 1985 which resulted in the breakthrough in Chemistry which led to the 1996 Nobel Prize for Bob Curl, Rick Smalley and me.





As for another interest, while at University, I shall be forever grateful to a friend Barry Callaghan who taught me just enough finger technique and chords to just get by playing the odd song or two on a guitar to perform occasionally at a folk club in a pub on Western Road in Sheffield. The chords and notes I could not play well, I sang over and the bits I could not sing, I glossed over with my fingers on the guitar. Here are three overage 60's kids on a sofa: Margaret is sandwiched between me and my friend and colleague David Santry in 1967 when David and I were working at the Bell Telephone Company in Murray Hill New Jersey. David was a quantum chemist who developed CNDO theory with Gerry Segal and John Pople. Pople was later awarded a share in the Nobel Prize with Walter Kohn for his contributions to Theoretical Chemistry. I shall be forever grateful to David for teaching me how to write a computer programme. Alas now I have practiced the guitar so seldom in recent years that my fingers tend to get trapped between the strings.



I also want to talk about creativity where the synthesis involves linking music to film. One of the most famous examples is the opening title sequence filmed by Saul Bass for the movie "Walk on the Wild Side" of a black cat stealthily ambling along to the powerful music of Elmer Bernstein which is in totality an unbelievable work of art.



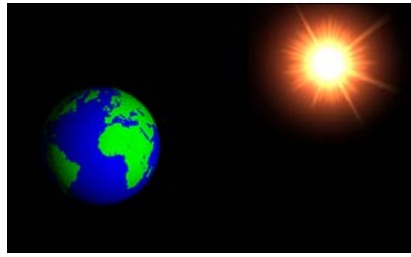
I think it is considered one of the first big advances in film by using a complete mini-movie as the opening credits. Listen on YouTube to the way that music and the moving images fit together perfectly. So, that again highlights what creativity is, in this case bringing brilliant music together with brilliant imagery. Another example closer to our home in the US is the melding of Ry Cooder's brilliant slide guitar playing with the desert imagery in the enigmatic film "Paris Texas" by Wim Wenders (also on YouTube). The opening sequence of Stanley Kubrick's "2001, a Space Odyssey" shows the Earth rising over the Moon's horizon and then the Sun rises over the Earth's horizon to the strains of Richard Strauss's powerful "Also Zach Zarathustra". This is also an unforgettably perfect example of the conflation of imagery and music. One of the most powerful antiwar moments in the whole of film is the frighteningly haunting vision of helicopter gunships swooping out of the sky to strafe a village during the Vietnam War to the strains of Wagner's "Ride of the Valkyrie" in Kubrick's "Apocalypse Now". This is a brilliant triple synthesis as the Valkyrie were the handmaidens of the Norse god Odin and as the myth goes, rode over battlefields deciding which "heroes" should die. Next is a beautiful frieze in New Zealand depicting the Valkyrie



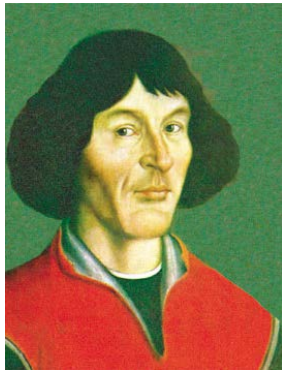
I have also designed a stain glass window at Florida State University to commemorate our Buckminsterfullerene discovery, After one of my lectures a member of the audience asked me "Have you designed book jackets?" and asked me to design one for a book she was writing entitled "Schrödinger's Fleabag". I much enjoyed coming up with the above image of a flea on the end of a cross-eyed cat's nose. Also I used Schrödinger's wave functions symbols which have become the iconic "logos" of Quantum Mechanics by placing  $\psi$  in one iris and  $\psi^*$  in the other. Next is my most recent logo design. Our two sons have a little company, Kroto Film and Design (KF&D), not that it is making much money. Our older son directed a short movie with Ian McKellen who kindly agreed to do a one-day shoot for him and here is the poster for that movie (which I did not design). Our younger son David is an artist who creates humourous satirical and political cartoons. While on a train thumbing through one of the many scores of graphic design books I have, with thought of a logo for KF&D at the back of my mind, I came across a block logo in the form of the letter "K" and then a few pages later the image of a pencil and I realised the logo above. In this the stem of the block "K", transformed into film silhouette by adding sprocket holes and the arm and leg part transformed into a pencil. This gives you an idea of how one of my favorite logos was created. Bringing images together and associating letters is yet another form of synthesis and gives me great satisfaction. Basically see what others have done and conflate images in a novel way to produce a different and new and original (creative?) design.

**Science**

Science is totally misunderstood. Let me give you first an example of one of the issues: "Common sense". Common sense clearly indicates that the Sun goes round the earth. Who agrees with me? Hmm...Nobody? I don't know what the Sun does here, but in Florida it starts somewhere over there and it ends up over here. The Sun "obviously" goes round the Earth. Who agrees with me? Hmm...One person!



Well it is actually “Uncommon Sense” that indicates that the Earth is actually turning on its axis which makes it seem as though the Sun is going round us on Earth, the “Uncommon” sense and bravery of Copernicus, Galileo and Giordano Bruno.



Well this is interesting. Our present understanding of the motion of the Earth caused a big problem for these three people. Galileo was threatened with torture by the Catholic Church and Bruno was burned to death by the Inquisition for claiming this and Copernicus’s Heliocentric Theory was not published until he was dead. Now it is very interesting that only one person here agreed with me that “Common Sense” tells us that these three people are wrong! Or are they wrong? Here is the most important point I have to make: Most people have accepted the fact that the Earth orbits the Sun without knowing the evidence!

### Evidence

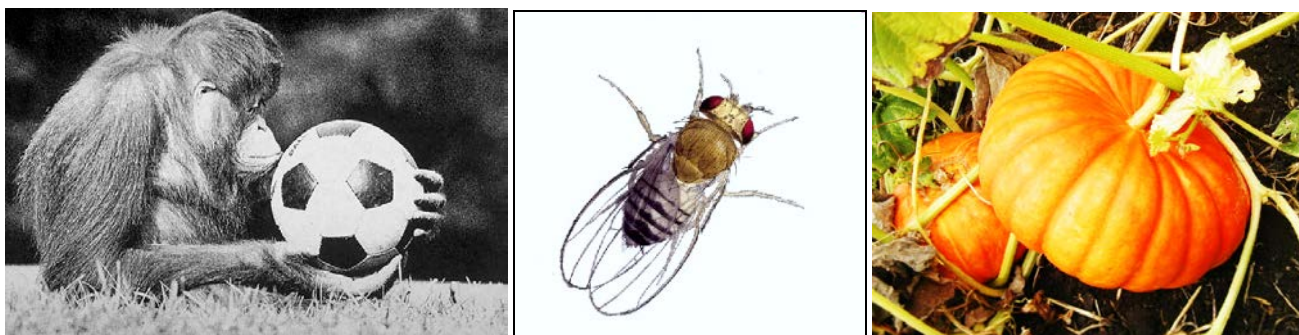
Question: How many of you know the evidence that proves that the Earth is actually turning on its axis? Hmm...Not a single person has put their hand up; I want you to think about that, because it is the first major lesson of today. The one that I want you to really think about, and perhaps maybe you hate me for making you think about it! Almost every one of you in this room has accepted the fact that the Earth orbits the Sun without knowing the evidence. Many people have accepted many things without any evidence and much of what they have accepted has no foundation whatsoever. This is the cause of some of the biggest problems in the World today. And I want you to ask yourselves: “What else have you accepted without evidence?” I want you to think about this very carefully because we are in a very dangerous world because huge numbers of people accept what are clearly fairy stories without thinking and there are many threatening people in authority who force others to accept these fairy stories as facts. This is one of the problems the World faces and the main reasons why we have so much difficulty achieving peace. So I repeat my main contention: Many people accept claims for which there is no evidence as true and this is a very, very dangerous situation for humanity.

The Pew Center (The Pew Center for the People & the Press, NBC News 2005) came out with these data for the USA: 44% of the population believe that "God created the world in six days", Genesis. 13% believe that "God is a divine presence". Only 33% accept Darwinian Evolution and 10% said they "don't know". We know some of the dire consequences of this.





The problem is that nonsense is common today. Common Sense, Uncommon Sense, now "Common Nonsense", and I am going to give you one example of this. There is this \$27M dollar museum just outside Cincinnati. Schoolchildren visit it in busloads and other groups as well. Displays of dinosaurs have questions and answers written above them such as: Q: "Did humans live with dinosaurs? A: "God made Adam and Eve on the same day as land animals, so dinosaurs and people lived at the same time". So I guess we must have put saddles on them and ridden them! Q "What did they (the dinosaurs) originally eat?" A: "Before Adam sinned, all animals - including dinosaurs - were vegetarian". Well, you don't think a Tyrannosaurus Rex needs teeth like that to eat a salad. Q "What happened to the dinosaurs that didn't get into Noah's Ark?" A: "They were drowned and buried by the flood and preserved as fossils". There is also a Noah's Ark, and Noah is a Scot! Well he's got a Scottish accent. The Disney-type dummy speaks in a Scots brogue presumably saying something like: "We've got to build a big boat, because a big flood is coming." And here is a photograph of little girl scratching her head presumably because she is confused by the contradictory and incompatible claims. Scientific analysis of the evidence indicates that the World is something like four-and-a-half-billion years old. So that's an issue.



Science indicates, very strongly, that this animal the orangutan is our cousin, and I am proud that 99% of my genes are the same as this wonderful guy. Just look at the humanity in the face. It is obviously a football supporter whose team has just lost. 70% are the same as a frog; 50% the same as a fruit fly (and the maggots as well). Yes we are related to the maggots! 70% are the same as pumpkins and you only have to listen to the average politician to see the evidence that that is a fact! There is more evidence for Evolution than any "truth" we have ever discovered. The evidence comes not just from Darwin's work which led him to write his famous book; it comes from chemistry, physics, geology, biology, geography, paleontology, oceanography, vulcanology, tectonic plates... all areas of the Sciences ...you name it. The attack of the Theory of Evolution, particularly in the USA by large numbers of ignorant people, is not just an attack on Darwin; it is an attack on the whole of the Sciences, and that's an important issue today.

**Contributions of Science to Society**

Let us discuss what science has done for Humanity. Let's look at penicillin. It works essentially every time; you don't have to pray. Now that's a miracle! In 3 weeks, this little girl in 1942 was cured. A year earlier she would have died, and here is one of



the unsung heroes of that story (Norman Heatley). Now, the future is terrifying because bacteria are evolving with an immunity to antibiotics. We must think about this and young people, like you, are going to face this problem in the future and we need brilliant young people to work out how to solve it.



I want you to have a look at this drawing of an operation in the 18<sup>th</sup> Century when there were no mobile phones to capture images. This is a drawing of an amputation taking place - without anaesthetic - by the famous caricaturist Thomas Rowlandson. I want you to have a good look at it and imagine yourself in an operation some 200 years ago. Women had mastectomies without an anesthetic! There can be no more humanitarian contribution from all of the sciences and particularly from the field of chemistry than the gift of anaesthetics. That is just a couple of the massive number of contributions of the sciences that have benefitted mankind. That is why the Sciences are humanitarian and as great a field of study for a career as you can possibly have. Unfortunately scientific discoveries are also used to the detriment of mankind and we must work continually to limit this dichotomous anti-humanitarian aspect.

But still Science is misunderstood at a fundamental level. People just do not fully understand what Science actually is. There are several aspects to it: The first is that it is the body of knowledge which we learn at school. The second is the application of that knowledge; Technology. The third is the many ways in which we discover new things which were not previously known or understood; "The Scientific Method". Much more important than all these however is something that has been forgotten, mainly because science is so fantastically useful people have either forgotten or never appreciated the fact that it used to have another name: Natural Philosophy, and in the perception of most people the incredible usefulness of science, the philosophical aspect that encompasses the scientific method, has been lost in the spectrum of human intellectual achievement. The most important aspect by far is that:

*Natural philosophy is the only philosophical construct the human race has devised to determine  
**Truth** with any degree of reliability.*

I shall rephrase this:

*The complete set of philosophical constructs which the human race has developed to determine what is **True** with any degree of reliability are the intrinsic algorithms of "Natural Philosophy"*

Thus the set of constructs we have devised to determine what is actually **True** are the fundamental principles of natural philosophy! In that case the ethical purpose of education must involve the teaching of young people how they can decide what they are being told is actually true. I hope we can all agree on that. Therefore the teaching of a skeptical, evidence-based assessment of all claims, without exception, is a fundamental intellectual integrity issue.

*Without evidence anything goes. Think about it.*

### **The Freedom to Doubt.**

The great scientist and great communicator, I think the greatest communicator of any kind, not just science communicator: Richard Feynman in his small book "The Meaning of it All" writes:

*"The freedom to doubt is an important matter in the sciences, and I believe in other fields.  
It was born out of a struggle.  
It was a struggle to be permitted to doubt... to be unsure."*

Remember that Giordano Bruno was burnt to death, Galileo was threatened by the Inquisition and the findings of Copernicus were only published after his death. (Continues quoting Richard Feynman)

*"And I do not want to forget the importance of that struggle and by default let it fall away.  
If you know you are unsure you have a chance to change the situation.  
I want to demand this freedom for future generations."*

This demand is for you young people in the audience and I think this freedom is under threat, it's falling away, it's a problem. Walt Whitman, the great American writer, expounded the issues better than anybody I know, he said:

"I like the scientific spirit, the holding off, the being sure, but not too sure."

The double take he uses is the mark of a great writer.

"...the willingness to surrender ideas when the evidence is against them,  
...this is ultimately fine  
...it keeps the way beyond open."

This last point is the most critical one. Whitman draws attention to an incredibly important issue. Science is open. It moves on inexorably, if someone makes a mistake we find it out. Our understanding of the universe advances and advances, it gets better and better and better. All other constructs are locked forever in unshakeable dogmatic opinion, intrinsically impervious to rational criticism. Because people believe things without evidence; so there is no argument, you cannot do anything about it. Because it is not true doesn't mean it isn't important to them personally, but untrue things are not important to me, and we must not be bound by the "untrue" beliefs of people who have no evidence to support their beliefs. Furthermore those who believe them often think that others should be bound by these unsubstantiated and unsubstantiated dogmas and foist their dogmatic attitudes on others. The danger of this is encapsulated in a quotation by John F Kennedy:

*The great enemy of the truth is very often not the lie -- deliberate, contrived and dishonest, but the myth, persistent, persuasive, and unrealistic. Belief in myths allows the comfort of opinion without the discomfort of thought.*

That last phrase – "The comfort of opinion without the discomfort of thought." - is truly brilliant!

Science is different from all the other things, it's simply the way it is. The way the Universe is. As my late great colleague Kappa Cornforth pointed out, everything else, music, the arts, books, politics, religion, etc etc., they're all constructs of the human mind. In that sense Science is absolutely different, and that is why there is a conflict in the minds of 90% of scientists including me with many of the things that people "believe".

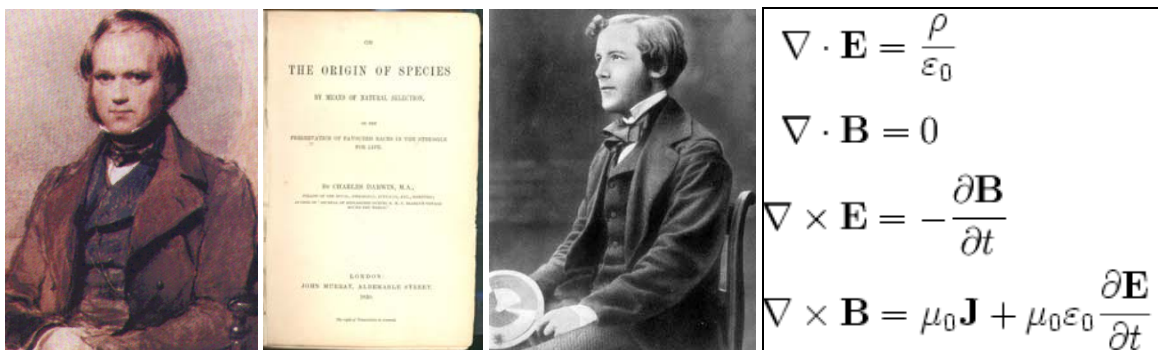
### The Real Scientists

Many people think that this is a great Scientist



Painting by Hans Erni

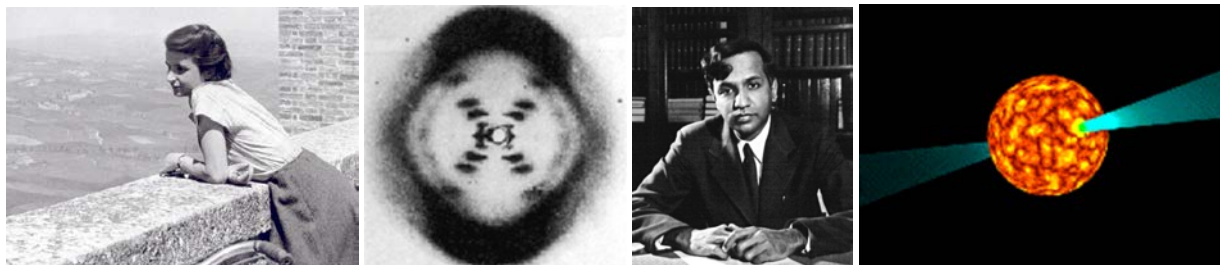
But oh how wrong they are. This guy is an imposter he is not a great scientist at all. It is the guy on the right who was the real scientist. Yes it was the young Einstein. In fact he was about 17 years old when he started to wonder what it was like to travel at the speed of light. He was about 24 when he discovered  $E=mc^2$ , the most famous equation of all time



Charles Darwin was a young man of 24 when he went on the voyage which led to his book on Evolution which changed our whole perception of who and what we humans are and how we came to be. The outrageous ignorant people who dismiss Darwin's (and Alfred Wallace's) conclusions and promote the trivial creationist lies in our schools deny the recognition by



young people of the most wonderful truth about the human race we have ever discovered. James Clerk Maxwell was a young man with a quiff when he developed his equations (here in the much simplified elegant and useful form developed by Oliver Heaviside) which underpin every aspect of electricity and magnetism on which so much of modern technology depends from mobile phones to washing machines. The young woman Rosalind Franklin shown here took the most important photograph of all time. It is the X-Ray image of DNA which led to the recognition of its Double Helix Structure. The future implications of this result are likely to have massive unforeseen (hopefully beneficial) consequences for the human race in the future. I only hope we have the wisdom to use the applications wisely – but I am not too sure! Subrahmanyan Chandrasekhar was a young man when he realised that a star about 1.5 times the mass of our sun would collapse into a neutron star or a black hole!



One is in the most creative phase of one's life when one is young. Creativity decrease with age and one hopes that the experience necessary for achievement which increases with age develops fast to reach a useful level before the creative spark has completely disappeared. These young people below were the crucial researchers who worked with us on the discovery and extraction of the C<sub>60</sub> molecule.



From the left Jim Heath, Sean O'Brien, Yuan Liu and Jon Hare

### Language and culture.

Let's go on to something else - Language and culture. Language - in all its forms - is the key to unlocking almost all important aspects of our world from the cultural creations of mankind to the mysteries and beauty of our Universe. In a Faraday discussion in Birmingham in 1954 on "The Study of Fast Reactions", the German scientist Manfred Eigen asked the Oxford Don Ronnie Bell how the English language would describe reactions which were 'faster than fast'. Ronnie Bell replied:

*"Damn fast reactions, Manfred, and if they get faster than that the English language will not fail you you can call them damn fast reactions indeed."*

That's English for you. If you want to understand Shakespeare at a deep level you have to understand English well, if you want to understand Goethe and Schiller you have to learn German and if I want to understand great Thai writers I have to understand Thai. It is essentially impossible for one person to really appreciate all the cultures on the planet. Can't be done! Let us consider this example of the Chinese (Kanji) characters in Japanese: "Mi-zaru, Kika-zaru, Iwa-zaru. Now zaru has a double meaning and translates both as no (negation) and monkey and therefore to the Japanese the characters possess a combined literal/visual sense: no-see monkey, no-speak monkey and no-hear monkey.



Thus we can appreciate only after an explanation of this beautiful double meaning why in Japanese there are three monkeys above the entrance to the First Shogun Tokugawa Ieyasu's tomb in Nikko. We might find a literal translation of the Chinese characters, but without a deeper understanding we cannot understand the deeper culture implicit in Chinese writing. On the right is the Chinese version of this saying written out for me by friend and former co-worker Yanqiu Zhu (unfortunately the who the kind Japanese calligrapher friend who created the Japanese Kanji has been lost in the nebulous neurons of my mind). In fact I really only know the meaning of the Kanji characters in the red circle. In Japanese they translate as Kro-To which means expert or professional. I often ask Chinese friends how they would interpret these two characters and they invariably scratch their heads because in Chinese it is an unusual construction. When pressed and after much deliberation they come up with a wide variety of conclusions from "magician" to "learned person". My favourite for obvious reasons is:

*"This man knows so much, you will never know how much this man knows"*

### The Language of the Sciences, in particular Physics

So let's talk about the language of Science, in particular the Language of Physics. The great American physicist ... (video of Richard Feynman is playing:

*"If you are interested in the ultimate character of the physical world, the real, the concrete world, at the present time our only way to understand that is through mathematical type of reasoning. That I don't think a person can fully appreciate, or in fact appreciate much of these particular aspects of the world, the great depth and character of the universality of the laws, the relationship of things: without an understanding of mathematics.*

*I don't know any other way to do it. We don't know another way to describe it accurately or even well, to see the interrelationships without it. So, I don't think a person who hasn't developed some mathematical sense is capable of fully appreciating this aspect of the world.*

*Don't misunderstand me, there are many, many aspects of the world that mathematics is unnecessary for, such as love, and which are very delightful and wonderful to appreciate and I don't mean to say that the only thing in the world is physics, but we were talking about physics and if that's what you're talking about, then to not know mathematics is a severe limitation in understanding the world."*

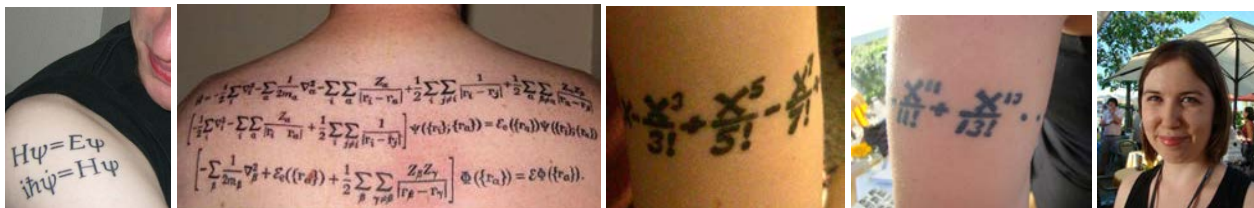
So, this is it, the language of physics, the language of the universe is mathematics. Galileo understood that. Newton understood it, and it was a long time before people realised that it really Algebra which is the fundamental language of science.

**It's just the way it is!**

I often say when someone asks me to explain something without mathematics:

*"Do you think I use mathematics to make my life difficult?"*

That would be like trying to give this lecture in Thai, when I don't understand how to do it. As Feynman says, it's not the only thing that is important, but if you want to understand physics...the way IT (The Univers) is... you will have to learn some mathematics. That's the way it is, not my fault. **It's the Universe's fault.**



Some young people really appreciate mathematics (The first three images are from the great book "Science Ink" of tattoos collected by Carl Zimmer). We see mathematical tattoos and I think these young people are making a personal statement that they do love mathematics. The first one is of the Hamiltonian Equation together with the Dirac Equation; the next is the

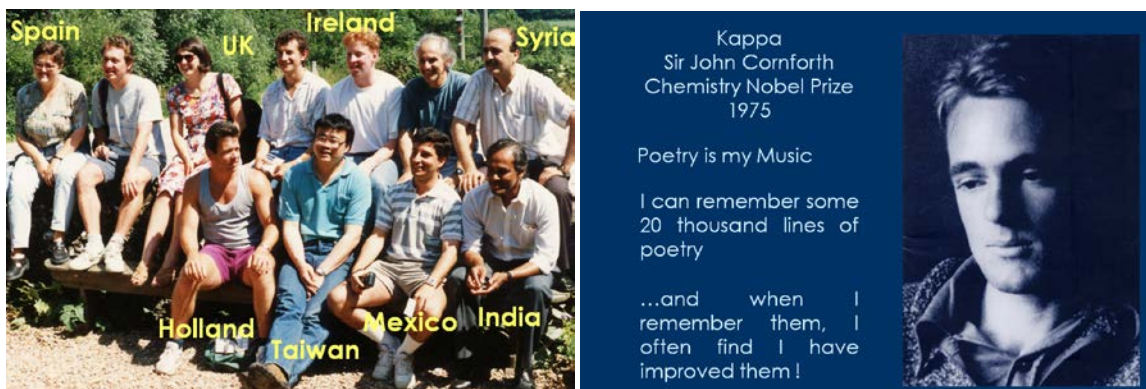
Schrödinger Equation for a molecule. Others have Maxwell's relationship, DNA, the Heisenberg uncertainty principle, LSD. The Buckyball and a Moebius strip. My favorite is this one (third and fourth above): Nicole a physics graduate student writes:

*"My tattoo is the Taylor expansion of sine", and listen to this, "I consider it the most beautiful thing I have ever learned."*

Isn't that wonderful? Here is a young woman saying that a mathematical relation it is the most beautiful thing she has ever learned. It's just like someone who has learned a beautiful poem by heart. Amazingly at a conference (Lindau) at which I presented these thoughts on scientific tattoos Nicole was present and I managed to take the 4<sup>th</sup> and 5<sup>th</sup> photographs above.

### The internationality of Science

Here is the group picture and it shows you how international science is. This is our group at the University of Sussex enjoying lunch on a beautiful day at a village pub in the country before I left for my present position at the Florida State University. We see researchers from all over the world. If you become a scientist you become part of a culture which transcends everything nationalism politics racial and religious. You become a citizen of not just the world but the Universe and that is the most important aspect.



### The written word

The written word is very interesting as well. (Sir) John (Kappa) Cornforth, who is shown here at the age of about 18, when he realised that he was going to be deaf for the rest of his life. Kappa, overcame this major disability to become a Nobel Prize winner. I met him for the first time in 1975, and I thought one had to be as smart as this guy to become a Nobel Prize winner. You don't need to be a genius like Kappa! I know from my own experience. You have to be a good scientist and work hard. He said something which I found truly fascinating:

*"Poetry is my music", this is interesting. It tells you something about people who are really deaf.*

He went on to say:

*"I can remember some twenty thousand lines of poetry and when I remember them...I often find out I improved them!"*

Some particularly favorite lines of mine (pointed out to me by a friend the astrophysicist Michael Jura) are from Shakespeare's Othello, again, you have to understand the English language to appreciate the rich elegance of the sentence construction and the sound of the words when spoken:

#### Iago

*"Good name in man and woman, dear my Lord,  
Is the immediate jewel of their souls.  
Who steals my purse steals trash.  
'Tis something, nothing"*

.... money, 'tis something, nothing...Here Shakespeare is telling us something important about money

*"Twas mine, 'tis his, and has been slave to thousands.  
But he that filches from me my good name  
Robs me of that which not enriches him  
And makes me poor indeed."*

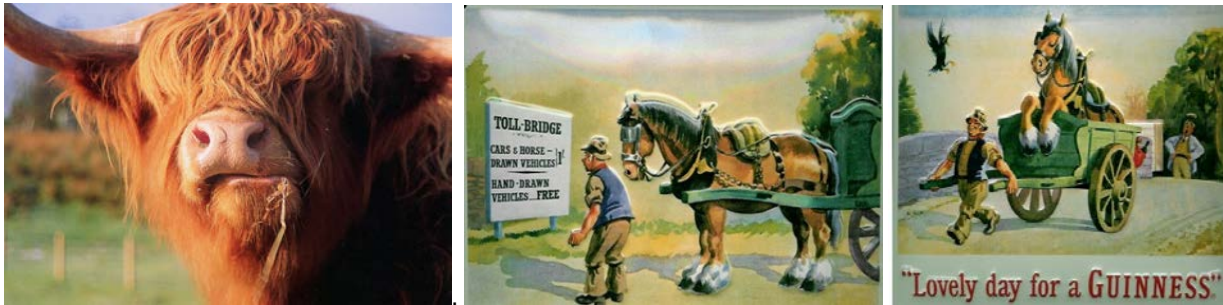
*(Othello by Shakespeare, Act 3, Scene 3)*

This sort of writing is why Shakespeare was a true genius, and one here can understand something intrinsic about culture, that without an intricate understanding of language one cannot understand a culture at deep level.



## Humour

Humour is very important too

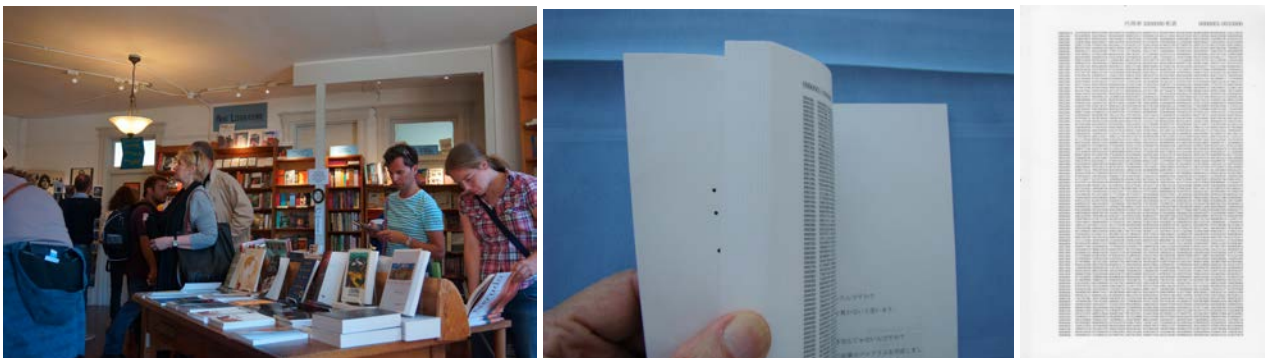


There you go. I just think that this image of a highland cow is delightfully humorous one. I don't know why, but it just is funny. A favourite cartoon goes back a long long time and I have the original magazine advertisement somewhere in my home and have kept it since I was a child. I thought I'd show it to you. The sign for the toll bridge (back in those days)" "Cars & Horse Drawn Vehicles - 1 Shilling; Hand Drawn Vehicles - Free". The next image shows the farmers's solution. That is what I call a truly imaginative humour advertisement – rather a rarity!

Another favourite humorous image is a drawing by David, our younger son. It is a satirical comment on modern art



I thought I would also like to show you one of my favorite pieces of comedy TV film. In fact it is considered to be one of the funniest moments ever in UK TV. It is the chandelier scenes which can be seen on YouTube from the sitcom "Only Fools and Horses" and I have never seen anyone not laugh at the ending of this scene. (VIDEO IS SHOWN) Now, this was creatively funny because of the slow build up to a totally unexpected hilarious final moment.

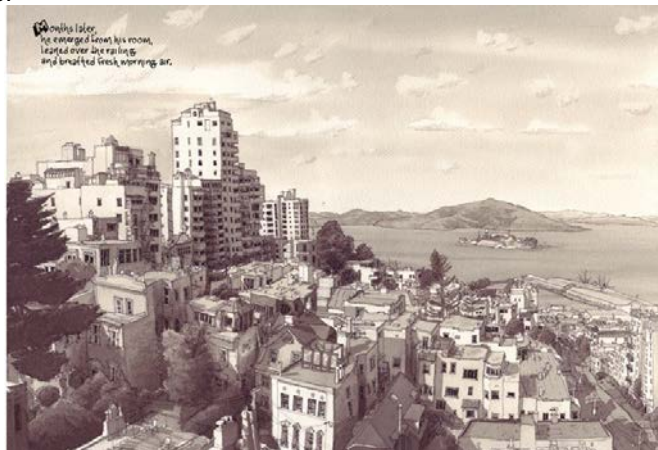


## Books and Bookshop

We cannot pass by a favorite bookshop "City Lights" (above left) in San Francisco without going inside and buying a book. We love are books of all kinds and I thought I should show you a really novel and interesting book. It's called " $\pi$ ". Now why do I find it interesting? It's  $\pi$  to one million decimal places! It's a Japanese book and you do not need to be able to read Japanese to appreciate it! On the first page you see the first row is  $\pi$  to one hundred decimal places, there are 100 rows on each page so on the first page it goes down 10,000 places on the first page! Now I am going to jump ten pages at a time, ten pages at a time, ten pages at a time, ten pages at a time, ten pages at a time, ten pages at a time, ten pages at a time, ten pages at a time, and here we are basically at the end, and here on the last (100<sup>th</sup>) page we have finally got to the millionth decimal place. And that's only one million! I think this book gives a good feeling for what the

number 1-million really can represent. I think we bandy about terms like one million, a billion or even a trillion (dollars) without thinking. We have lost our understanding of what the number 1-million actually is. It's a lot. A million dollars is a lot of money. There are 30-million seconds in a year. And the last number - the millionth decimal place is 1. And also on the cover we see Japanese humour: The cost of the book is 314 Yen. ( $\pi$  of course being 3.14+). So that's a book I find interesting which tells us something important about numbers!

Another favourite book is "All Over Coffee" by Paul Madonna with beautiful pen and wash drawings of buildings, streets and areas, mainly of San Francisco.



They often have eclectically subversive captions such as: 'Set your ideals to those of the image of your idol, pull your collar tight and walk into the storm'. One I particularly like is: 'Take a stand and automatically, you have a supporter and an enemy'. The problem today is that too few people are prepared to take a stand against inhumanity, mystical dogma, ignorant authoritarianism and the pure greed of rich people in positions of power and political influence that we see in life today.

### Global Educational Outreach for Science Engineering and Technology (GEOSSET)

So what am I doing? I am trying to do something novel for education. The initiative I have setup is the project called Global Educational Outreach for Science, Engineering and Technology (GEOSSET). We use a capture station which is a basically a computer system which synchronises the video recording of a presenter with the data files (say Powerpoint etc) being presented. I actually do not need to be here I could come to you by Internet. I now "go" by Internet to India and other places perhaps half a dozen times a year. I want to show you what our students do. They are fantastic.

If you go to [www.geoset.info](http://www.geoset.info) you can see numerous recordings of scientists as well as many by graduate and undergraduate as well as high school students. A typical one is this presentation by Undergraduate Vinnie LaBarbera about beetles (<http://geoset.fsu.edu/projects.html>) arguably more rather important than "The Beatles" with an image of whom he introduces his presentation!

Click for full-screen mode

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### Fireflies

D-Luciferin ((S)-2-(6-Hydroxy-2-benzothiazolyl)-2-thiazoline-4-carboxylic acid, 4,5-Dihydro-2-(6-hydroxy-2-benzothiazolyl)-4-thiazolecarboxylic acid)

O=C(O)C1=NC2=SC(=O)C=C2S1

O=C(O)C1=NC2=SC(=O)C=C2S1
 $\xrightarrow{-\text{ATP}}$ 
O=C(O)C1=NC2=SC(=O)C=C2S1
 $\xrightarrow{\text{O}_2}$ 
O=C(O)C1=NC2=SC(=O)C=C2S1
 $\xrightarrow{-\text{AMP}}$ 
O=C(O)C1=NC2=SC(=O)C=C2S1

Light + CO<sub>2</sub> + O=C(O)C1=NC2=SC(=O)C=C2S1

<http://www.chemistryexplained.com/Ar/So/Techniques/009.htm> (pic)

It turns out that students are very good in creating educational material like this and adding to the "Global Cache of Knowledge" (GCOK). A second presentation by a research student (Grad Student Kerry Gilmore) is about organic chemistry which describes designing molecules. Kerry says that as a chemist one can be an architect and an engineer on a molecular scale, on a nano-scale. See, you don't have to be an architect who builds buildings necessarily; you can get the same thrill out of building structures on a nano-scale that you can on a large scale. It is usually a lot cheaper too. I had better jump on now because we are running out of time. We have got recordings on inbreeding in a wolf pack trapped on an Island for 70 years and numerous presentations which teachers can use for their own lessons.

Furthermore look at what we have done for assessment. Instead of a pile of paper that a teacher has to spend hours reading and marking laboriously, giving them a headache at best, they can sit and drink a glass of wine and enjoy listening to and seeing students giving a presentation, which is what I am actually doing in the image near the beginning of this lecture.

We have basically revolutionised the resumé as well. We put our students on the top of a pile of applicants because we insert the URLs of student recordings in their references making the lives of the assessor very easy and perhaps even enjoyable. Here is our Hall of Fame: Kerry (the second recording shown) got a Fulbright Award; Steve put together a great overview of GEOSET and we got a Rich Media Award; Prajna the first student we recorded got four year tenure track offers and was told that the GEOSET recording showed that she could teach; Brittany got into medical school and said the GEOSET presentation was the defining factor; Artrease, one of my students, was told as she walked into the room for an interview for a scholarship that the committee had enjoyed her GEOSET presentation and this immediately put at her ease; Jennifer got into Vet School; Dan got a Goldwater Scholarship and Noriyuki (at one of our Japanese nodes) got a job at NHK the major Japanese TV company. The most interesting GEOSET success was this one: Saino is an Indian researcher who was working in Japan and she sent the URL of her presentation on GEOSET to the Mahatma Gandhi University and she was subsequently hired as an assistant professor. So GEOSET can give you a pre-interview accessible worldwide. My FSU Physics colleague Mark Riley in a report to NSF sent the URLs of recordings to the assessors and they were pleased to see the students they were funding. GEOSET really works in a multitude of ways. Steve Acquah, Sam Ruston, Colin Byfleet and Penny Gilmer, shown here, are people who are making GEOSET a success.



### Some Important Humanitarian Issues

If you become a scientist, you should become involved with organisations that have something to do with societal responsibility. This is just one: the International Network of Engineers and Scientists for Global Responsibility (INES). If you are a physicist, we don't need any more atomic bombs; if you are a chemist we don't need any more napalm; and if you are an engineer, we don't need any more landmines. You can see video of little kiddies with one leg, the other blown off by a land mine, playing soccer on crutches and dreaming of going to the Paraplegic Olympic Games. We don't need any more of that. Leon Lederman, Nobel Prize in Physics in 1988, sent me an email saying, Harry, you see a lot of young people. Can you say this for me:

*"So many years have passed, and the human race is still saddled with enough nuclear weapons to destroy the planet. We must redouble our efforts to unify the science community against this huge stupidity!"*

It's not just the science community, it's the whole community. Scientists are only 1 or 2% of "the community", but they are the 1 or 2% who created the modern world. Computers, lasers, the paint on the wall, the material on the floor, the lights and the electricity: all this was created by 1 or 2% of the world. We need to unify the other 98% of the global community.

(Sir) Joseph (Jo) Rotblat became a close friend in the last years of his life. He was the greatest man I knew personally. He was actually one of only one or two scientist to leave the Manhattan Project before the war in Europe was over and before the Atomic Bomb was actually completed and when it was clear that it was not needed as a deterrent as Hitler did not have a bomb. If only all the scientists had left. In his Nobel address he said:

*"We appeal as human beings, to human beings: Remember your humanity and forget the rest. If you can do so, the way lies open to a new paradise; if you cannot, there lies before you the risk of universal death. The quest for a war-free world has a basic purpose: survival. But if in the process we learn to achieve it by love rather than by fear, by kindness rather than by compulsion: if in the process we learn to combine the essential with the enjoyable, the expedient with the beautiful, the practical with the beautiful, this will be an extra incentive to embark on this great task.*

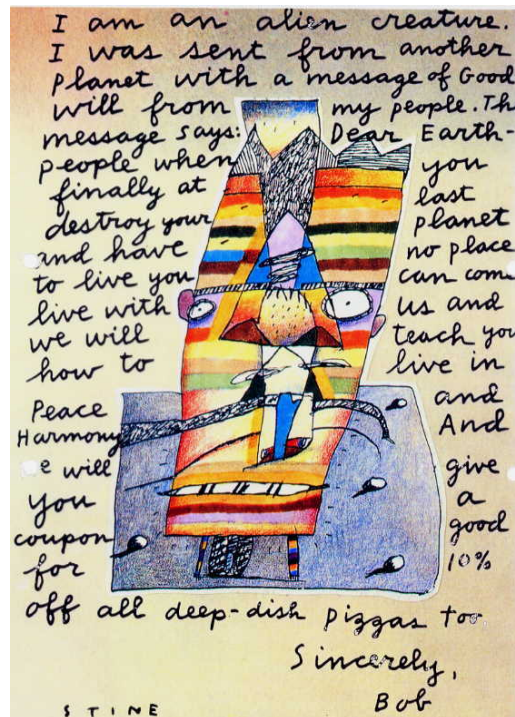
*Above all, remember your humanity... and forget the rest."*





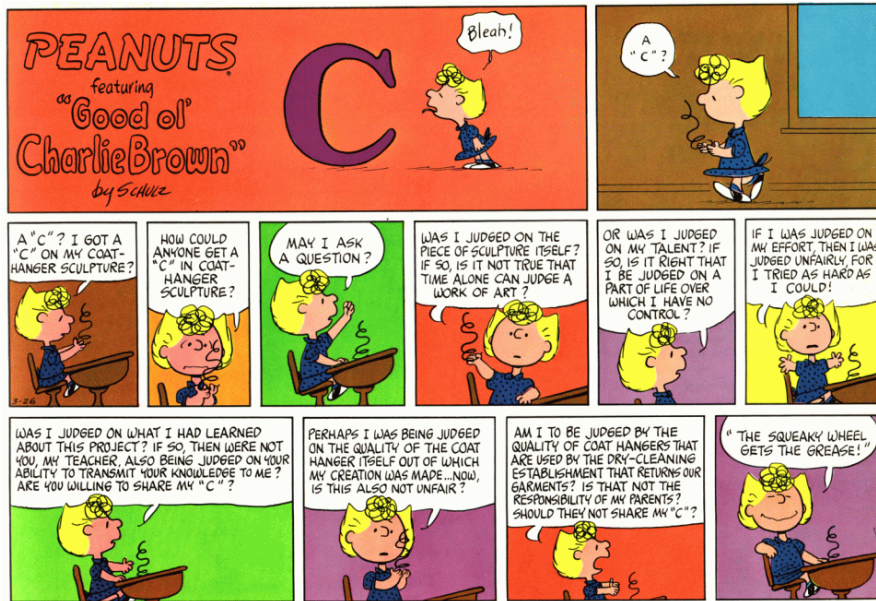
Here is Jo, who was awarded the Peace Prize with Pugwash, in his office. He spent most of his life, from the age of 30, with Pugwash focused on stopping the proliferation of nuclear weapons. Here he is in his office where we recorded interviews with him, and look at that stack of papers just to his left shoulder, how are they staying up?! I do not know!

A favourite poster; when I first saw it I fell in love with this poster by Richard Stine:



This poster makes three points: The first issue highlighted is destruction of the planet. I am a scientist, so I am not sure, at least not absolutely sure on such a complex issue, but as far as I can see things just do not look too good for the future of our planet. I think we could be destroying it, and as I am not sure and this is a serious issue I think we must err on the side of caution and put into practice some major sustainability measures as soon as possible. We must do everything we can do ensure that we are not making things worse. However we are not doing anything effective ... and that bothers me. The second thing Stine mentions is "Peace and Harmony" and I am pretty sure about this. Is it not incredible that we cannot solve our problems by sitting down together, to try to solve these problems without sending young people to kill each other in wars? Day-in-day-out, there are some 29 or more conflicts (a euphemism for wars) going on at the present time. Basically there are scores of conflicts of all kind, some involving terrorists, going on at this moment. We are in the 21st century with weapons of mass destruction, and we still cannot solve our personal problems by sitting down together at a table. We all know this makes sense. However there is a third observation on the poster which whimsical and powerful at one and the same time: The offer of a "deep-dish pizza". This is a beautiful example of humour focusing on the stupidity of the human race highlighted in the first two points. Life is just not worth living without a sense of humour; at least as far as I am concerned.

I am going to finish now with an aspect of education, which I want you to think about. It is my favorite Peanuts cartoon (by Charles M. Schulz) and it is quite incisive about most aspects of education



However let's see what Sally in the fourth frame asks: 'How can anyone get a "C" in a coat hanger sculpture?' Well, I am now going to show you. The most amazing coat hanger sculpture one could ever imagine was exhibited in 2010 the Royal Academy summer exhibition in London. In fact if you are ever in London during summer you must go to the Royal Academy summer exhibition, it's a British cultural cult. In 2010 there was a sculpture (by David Mach) and here you see in close up a few coat hangers; more than one; we all can agree on that. However, let's have a look at what it is. A gorilla statue that is bigger than the people standing next to it, made completely out of coat hangers. Now that's a coat hanger sculpture!



And I use this as an example for young people to think about. Whenever you have a project, you start the project, and you think of this gorilla and say: 'I am going to do something fantastic that no one else could have imagined, something that is an A+++++'. You can now see why Sally actually deserved only a "C" by comparison. I think it is one of the most amazing pieces of imagination I have ever seen. So when you do anything, anything at all, whatever project it is, think about the gorilla and say, how can I do something amazing like this?

### ATTITUDE

The way to create your personal "Gorillas" has everything to do with your "attitude". Look at this little boy. Margaret took this photograph, this is the boy that I showed you at the beginning, totally engrossed in what he's doing. He is making a model Buckyball.



This has everything to do with education – creating the “prepared mind”. Noah does not care about prizes or whatever, he is totally focused on the hands-on experience of creating something and it’s all about attitude. My simple recipe for success in general is this:

*When you do an assignment make sure you give it the best shot. If you are satisfied with second rate effort on a project, look for something else where only the best effort, will satisfy you. Not the teacher, you personally. If you do this all the time, you will invariably find that you will do everything better than other people who might have been able to do things better, because they are smarter than you or me but they do not because they do not have your level of determination.*

There are plenty of people who are smarter than I am but they are never going to win the Noble Prize, not that that's important; I never set out to win the Nobel Prize. I didn't do things because I thought they were important, I just did things that puzzled me or interested me personally. I always did just things that interested me. It turned out that in an experiment which did not appear to be that important to others, even the colleagues whom I convinced that we should do the experiment, turned out to be one of the most important experiments. Indeed deemed sufficiently “important” that it led to the Nobel Prize. So my advice is just do what you're interested in doing and find satisfying; don't do things just because other people think they are important. If you do that, you will do things better than other people, perhaps things that they will not consider doing (this means less competition too) and do everything with determination and I predict you will be successful.

*So, there it is: I'm only here to make you think!*

Thank you.



**Question:**

If we have been educated in principles and tradition and discipline, what is the first step in making creativity?

**Prof. Kroto:**

I think, what you have to do is look at a problem and try to see it in your own personal way. You can look at what others have done and basically steal it but present it in another way adding your own perspective. Picasso said something which applied to this. This is Picasso's contribution to creativity, and it is basically: "The bad artists imitate, the great artists steal." It's actually a bit facetious and it's been crossed out and is signed "Banksy, who is a rather famous street artist. What it's really telling you is that you look at what others have done and see it in a different way, try to do it in your own personal way and in fact, to some extent, I showed you this logo because I rather like it and I'll show it again because it seems to me that it epitomises synthesis as an aspect of the creative process, in fact the way I think. I saw these two images, the block "K" and then the end of a pencil and put them together, I like them both very much, and put them together in a way that was appropriate for the logo of Kroto Film and Design. Again, one of Pasteur's statements, 'to see what others have seen, but think what no one has thought'. That means you have to develop your own personal way of looking at the world to jump forward. In science we can't move on without knowing what other people have done, so it's not so much as stealing, but looking at what they've done and then seeing how you might apply their results in a different way adding your own expertise to solve a new problem and make an advance. You get the idea?

**Question:**

I am so moved and touched by your concept "Freedom to doubt" and that hits me right on the dot, and as a professor and a Nobel Laureate I would like to ask you to please share how you could nurture the freedom to doubt in the young minds and first of all, since I feel that I am forever young, even though I am in my 60s, alright, so I am doubtful of what you have shared with us earlier, because you did mention that there are three senses. And since I am so young I jotted now four senses, so I want to know what are the three senses that you were mentioning?

**Prof. Kroto:**

Common sense, uncommon sense and common nonsense are the three senses I talked about and pointed out then Nonsense is common now.

**Question:**

What about the sense of humour?

**Prof. Kroto:**

Well, that's another thing. My three senses were common sense, uncommon sense and common nonsense. But the freedom to doubt is probably more important, and I think that presents the teacher with a big problem, because they have to have courage. The courage to encourage their students to question what the teacher is actually teaching them. That means that when a teacher has made a mistake they are able to admit that to the class, and that's sometimes a difficult problem, and I have had problems like that myself. So I try to make sure that when I teach I don't make too many mistakes! But if I do make a mistake, and one of the most important aspects of a scientist is to recognise that mistakes are often made, that when you make them, you admit them. Then the students realises that teaching is not about the teacher being correct, but teaching the method whereby you learn.

I remember very strongly when I came home from school one time and I told my father that something the teacher had said that day was not correct. He said that teachers cannot be right all the time, they're human beings, they will make mistakes too. So I learned that we will all make mistakes. First of all if you make them, you make sure to admit that and that's a good lesson, not just for me but for my students too even though I might find it difficult. But it is a challenge that the teacher must really instill in young people: doubt and questioning, because without those the human race is stuck in a rut, and I think a lot of us are stuck, I think that this is one of serious the problems that we face today. Today dogma - basically authoritarian claims with no evidential basis - is controlling many of the actions of countries and large groups of people; and it bothers me. Many of these people do not seem to have a sense of humour, but for me life without humour is not worth living.

**Question:**

It might be too difficult for me to ask any question, but I would like to say that you are a great leader. And a teacher is a leader, so you are a great teacher and leader.

**Prof. Kroto:**

Oh no! I wish I were!

**Question:**

I say you are a great teacher, because you are trying to help us to know something without teaching. You are not teaching, but you help us to learn and help us to think. At the same time when I say you are a great leader, it is according to my definition, a leader is always adding value to other people. You add value to many people, including the audience. The

second part is: You add value to your work, we understand your work easily, and at the same time you add value to yourself that you give us to understand that to be a great leader you have to know everything in something and know something in everything. I believe that the audience agrees with me. I appreciate your lecture.

**Prof. Kroto:**

Thank you.

**Question:**

I would like to ask you why the scientific community don't put more research thought into how you achieve peace and how non-violence actually works and how it can be an answer to some of the problems we face? I came here, to this country 51 years ago, as a member of the Peace Corps, the United States Peace Corps. We celebrated our 50th anniversary, and it was on volunteerism in Thailand. That's 50 years now since the time of Martin Luther King and Mahatma Gandhi, I just don't see much research and effort going into finding peace. For the military we invest billions, and the amount of money we give for research is less than it was and the universities aren't getting what they need for research. But it seems to me that with all the emphasis "Bridges for Peace", this is what brought me here today more than anything and I just don't see this bridges being built unless we really put some effort into it, and I wanted to know what you might think about that, as a scientist.

**Prof. Kroto:**

I do think that many scientists work for peace. Jo Rotblat, Leon Lederman and other and people like Richard Feynman have talked about this. But peace is not a scientific issue, it's a social issue, and I think, as I said in the last part of my talk, I really don't understand how it is that we with our democratic socio-political infrastructure produce political leaders who find it essentially impossible to sit down at a table and discuss the problems that we have. I find this quite incredible in the 21st century.

I do think that among the scientists I know - and I know a lot of Nobel Prize winners, people like Elie Wiesel and Jo Rotblat, these are people who did work for peace. I think we've done a reasonable job, but we are a very small group of people and as I said, the number for people who have doctorates in science is about 1 % of the population even in the USA.

I think the problem is in education. How is it that we still, through our educational systems, produce people who find that the only solutions to international problems involve armed conflicts. We have to look at some parts of the world where dogma is being distributed. A dogma of antagonism towards people who are not the same as ourselves. In the USA we have intense nationalism or patriotism. I think it's a country which seems to value this, but it's not really a good value because survival today is a global issue. Americans will not survive unless they recognise that we are all members of the human race. The fact that in general our political, social or financial infrastructures are highly nationalistic is detrimental to the survival of the human race. Politicians in Britain encourage people to accept inward looking policies which are focused on national self-interest and such socio-economic and socio-political somewhat xenophobic attitudes I find very disturbing. I lived in the States just after Kennedy was assassinated and I think the biggest thing that I have witnessed between then and now is that 'being liberal' has become a dirty word. However a Liberal attitude is a scientific one, it means being open and thinking about alternatives and not being dogmatic. This new antagonism bothers me as being open to discussion is something that I hold very dear to the way I think; to be open to new ideas and to be prepared to answer questions and recognise that for the human race to survive we must strive to work together on an international level. We must work with people throughout the world, because what is best for America and Britain and Europe is the same as that which is in the best interests of Asian and African countries as well as Latin American countries. So those are the issues, and I don't think they are intrinsically scientific ones, I think they are socio-economic and socio-political ones. However they do have something to do with recognising that dogma is unsubstantiated by evidence and I suppose that is a scientific philosophical perspective. We must recognise that dogma is just a human construct and may lead to unreliable socio-political and socio-economic strategies. There are religious issues, as much as there are political ones, and I think until we get these matters sorted out very serious problem will remain for young people in the future.

I used to be an optimist. When the interviewer intimated to Leonard Cohen in a "Rolling Stone" magazine interview that he was a pessimist he said: "No. I think of a pessimist as someone who is waiting for it to rain. I am drenched to the skin". Well I say, "I'm an optimist." Why? "Well, I will be well out of here when the shit hits the fan". That is my level of optimism! However I think you young people deserve better. I think we really do have to work on making things better. We have to take our leaders and make sure they all sit down together. The Obamas and Putins, the Chinese leaders and all the others, they have got to come together, because what sort of example is that for our young people. The Japanese and Chinese are having ridiculous problems; Terrible conflict between Israeli's and Hamas; how can we expect a future of peace when our leaders can't sit down at a table together. That's why I loved Jo (Rotblat). He was revered by people on both sides, by Gorbachev and others who recognised just how hard he worked for the non-proliferation of nuclear weapons.

This is something which Uwe here is working for, to try to bring people from all over the world to come here and say to young people that we can work together for a better world. Unless we do that we are not really going to solve the problems. It's not a scientific one, it's a socio-political one and I think religious conflict is a primary catalyst at the present time. That's a problem because people believe in myths which are very important to them and this can be dangerous. I worry about the organisations which take advantage of what people believe without evidence. These problems have something to do with society and I think irrational attitudes are often taken advantage of by people at the top of powerful political and religious organisations and that is not the way it should be. Organisations that believe dogmatically in either Capitalism or Socialism

are dangerous and slide towards totalitarianism when careful thought and experience suggest strongly that a subtle blend of the two may be an optimal socio-political/socio-economic strategy for survival.

**Question:**

I am specialising in chemical education and I am very interested in what should be the role for you, as a scientist, to get young people more interested in science?

**Prof. Kroto:**

What I do is basically shown in this first picture. One thing I am doing is science educational workshops with 6 to 8 year old children around the world. I have done these in Japan, Germany, the USA, dozens of them in the UK as well as in Malaysia and Mexico, indeed all over the world. The aim is to get kids as in this picture to be totally engrossed in something. That's the main thing I am doing and trying to work on. As I showed you before, I want young people to be creative and think about scientific issues, for instance this presentation made by an undergraduate. (A presentation from GEOSET is shown)

These recordings were made by students on one of my courses at Florida State University. I asked all the students to find a little project on something that they found personally interesting and then record a short presentation. They were all remarkable, but this by Jennifer was perhaps the most remarkable recording. She describes a published study of a pack of wolves that crossed an ice bridge onto an island in the Great Lakes during a very cold winter in the 1940's. As ice has never formed since the pack has been isolated on the island for some 70 years. All the wolves are related to one female and 2 or 3 males and all the wolves today have serious problems such as highly defective vertebrae due to inbreeding. Jennifer then went on to relate these findings to her personal serious concerns about the fact that intensive forced-inbreeding in so-called puppy mills results in pedigree dogs with serious genetic defects.

Now, the way to do it is to take students and let them do what interests them. I think education today is a problem because governments and government committees decide what you should know. You've got to know something, you definitely have to have a ground work of knowledge, but you also have to know something else. One is to find something interesting and Jennifer found this fantastic study where now 100% of these wolves have massive problems. Now, she goes on however, and this is the thing, not just finding this study, she goes on to put in what she is interested in. (continues presentation from GEOSET) So she used this to highlight an issue which she is particularly angry about - inbreeding and puppy mills. But this is the interesting part, not only did she produce something very interesting for me but this amazing 70 year study in inbreeding will never be repeated it would be unethical to set something like that up. The big advantage, as I showed before is that Jennifer got into Vet school and her presentation on GEOSET helped her to achieve this.

So, the way to do it is to encourage young people, like you, to use your spare time doing something that fascinates you such as a scientific project and make a presentation on it. I hope a GEOSET project will be set up in the school where we have been this morning, Shrewsbury International School, which was keen for students to realise their true potential in the future. So it is basically finding some way of encouraging all creative potential within the sciences. But not just the sciences, something that you are personally interested in.

**Question:**

Thank you very much for your great lecture. Do you agree that we try too much to put the academic knowledge to our students and then, that's going to interfere with creativity and imagination. Do you have any idea how to solve this problem?

**Prof. Kroto:**

I think I did address it. I think the problem is not teaching what to think but how to think and you can only do that by example. And I think within the sciences and the universities it is absolutely vital that the undergraduate students spend time in the research labs, because you don't learn how to think from a book. From a book you can learn what is known. What you need and what is important is that you learn how to think and how to do research. We somehow learn how to be creative osmotically by being in a creative environment. In fact if you think about the old masters, Leonardo da Vinci worked in Piero della Francesca's studio. So, in the old days there were apprenticeships and those apprentices would work in the studio of the master and would paint something and gradually in some cases become better than their master. Scientific research is carried out in a similar way as a senior research scientist builds a research group and research students work together in a synergistic consortium; or that is the way I tended to organise my group. Science today is a communal activity. Although there are still one-or-two scientists who do work almost alone they are rare exceptions. The days are really long gone in experimental science where one could work by oneself. It is too difficult and complicated and the equipment is sometimes very complex and requires people with a range of highly specialised abilities.

I think the emphasis should be far more on hands-on in schools, which I think is happening. That little boy I showed was totally engrossed in what he is doing and that is so beautiful to see, a child working away, trying to construct tangible things with their hands. To become a good scientist, that is someone who discovers new knowledge, you have to be immersed in an environment where good research is being carried out. This is like a process of osmosis, acquiring skills almost unknowingly from the surroundings. You don't understand something, but something happens and then the emotions come in, then you have discussions and work together and then something happens unexpectedly. There is now far too much emphasis on what a committee decide you should know and do. Scientists I have interviewed in general have said their attitudes were influenced by a teacher and by and large not to do with their academic discipline.



